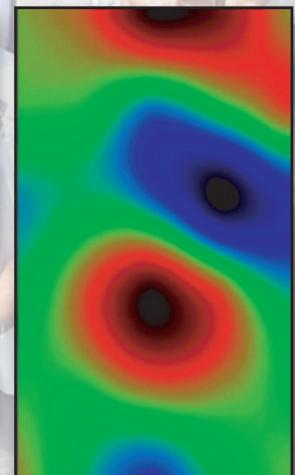
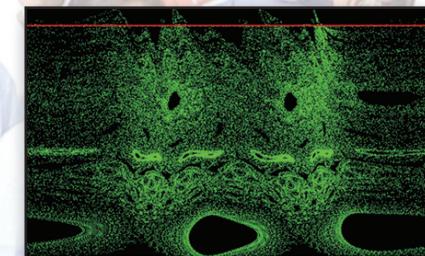


DIII-D National Fusion Program Overview

by
D.N. Hill

Presented at
FY10 Budget Planning Meeting
Office of Fusion Energy Science
Washington, DC

March 11–12, 2008

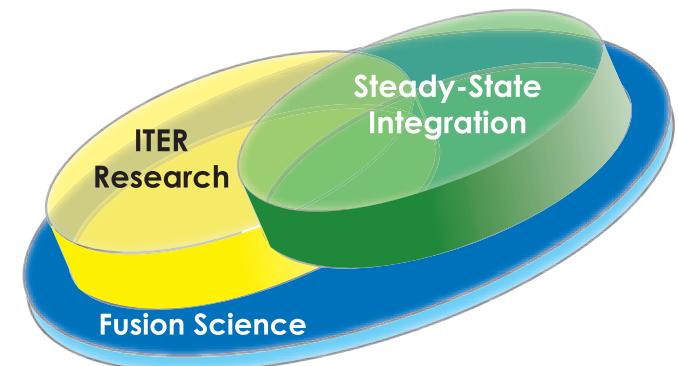


The DIII-D Program is a Science Program With an Energy Goal

- The DIII-D program elements are strongly synergistic and overlapping

DIII-D Mission: to establish the scientific basis for the optimization of the tokamak approach to fusion energy production

- **ITER support:** Enable the success of ITER by providing physics solutions to key issues
 - Strong collaboration with ITPA, US BPO, US IPO, and international partners
- **Advanced tokamak:** Establish the physics basis for steady-state high performance operation for ITER and beyond
 - Our vision of attractive fusion energy production
- **Science:** Play a lead role in advancing fundamental understanding of fusion plasmas along a broad front
 - Validate predictive models
 - Transport: understanding and control of turbulence

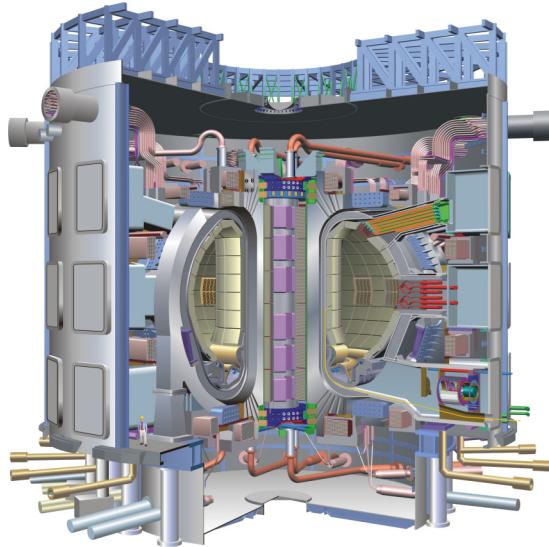


ITER research — 80%

Steady state — 60%

Plasma science — 100%

ITER is Our Future!



ITER Mission:

“to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes”

- **ITER Technical objectives**
 - 500MW, $Q > 10$, 400 sec inductive discharges
 - Aim at steady-state with $Q > 5$
- **Our DIII-D Program plan actively supports these ITER objectives**
 - Establish the physics basis for high-gain operation
 - Develop integrated steady-state scenarios

We Are Working to Make ITER the Best Burning-plasma Experiment Possible

Our work in

Hybrid Modes

Steady-state, High Gain

Resistive Wall Mode Stabilization

NTM Stabilization

Real Time Control and Disruption Mitigation

Energetic Particle Physics

Turbulence and Confinement

Rotation Physics

Pedestal Physics

RMP Coils and QH-mode

Erosion and Material Migration Studies

May Enable in ITER

Achieving baseline mission at lower machine parameters

High fusion power in pulses of an hour or longer, possibly true steady-state

High performance, steady-state operation

Removing a possible limit to baseline scenario performance

Low frequency of disruptions and mitigation of their consequences

Good preparation for alpha physics

Solid basis for ITER performance

Rotation control for improved performance

High performance

ELM free operation for long divertor lifetime

Use of the graphite divertor to achieve baseline mission

The DIII-D Team is Strongly Engaged in ITER Through National and International Activities

- Informs the DIII-D program
- DIII-D program impacts the fusion community

International Tokamak Physics Activity (ITPA)

- Members (40)
- International chairs (3)
- US leaders (8)

US Burning Plasma Organization (USBPO)

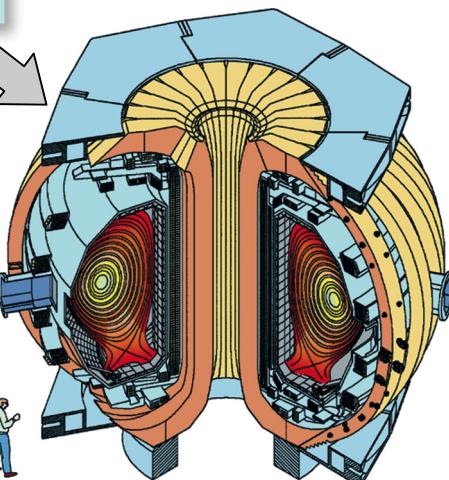
- Deputy Director
- Research Committee (7)
- BPO Council (4)

Transport Task Force (TTF)

- Chairman
- Executive Committee (5)

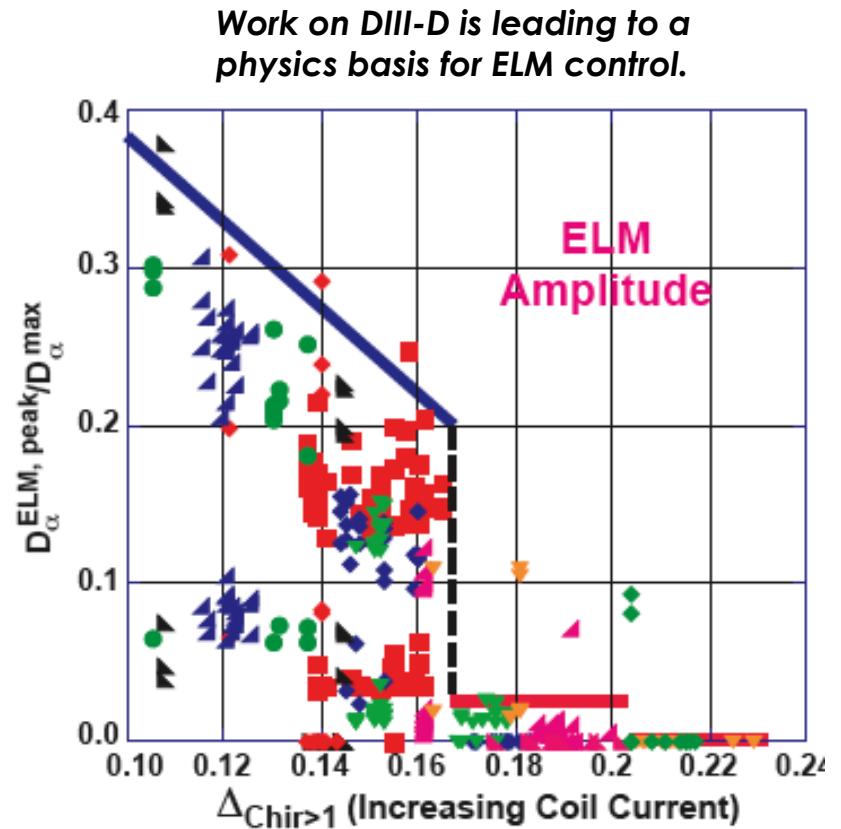
ITER Design Review Activities

- Design requirements and physics objectives WG
- In-vessel components WG
- ITER Research Program Planning Group
- Strong contributions to specific design activities,
 - RMP ELM control
 - RWM
 - Vertical stability
 - ITER startup
 - Disruption mitigation
 - ...



2008 Research Plan Supports US Burning Plasma Organization High Priority Research Tasks

- More than 2/3 of experiments in January address ITER research needs
- 2007-2008 BPO focus: Provide scientific input to the ITER design process.
 - ITER Research plan
 - Sensitivity studies
 - Disruption studies
 - Vertical stability
 - Choice of PFCs
 - Startup scenarios
 - RWM and ELM control coils



US BPO Mission: Advance the scientific understanding of burning plasmas and ensure the greatest benefit from a burning plasma experiment by coordinating relevant US fusion research with broad community participation.

DIII-D 2008 Research Plans Support ITPA Joint Experiments

<u>Expt. ID #</u>	<u>ITPA Topical Group</u>	<u>Experiment description</u>
CDB-10	Conf. DB and modeling	Power hysteresis and access to H-mode with H=1
TP-4	Transport Physics	Transport dependence of high perf. ops. on low external momentum input
TP-6.1	Transport Physics	Scaling of spontaneous rotation with no external momentum input
TP-6.2	Transport Physics	T-60U/DIII-D Mach number scan similarity experiment
TP-6.3	Transport Physics	NBI-driven momentum transport study
PEP-2	Pedestal Physics	Dimensionless scaling of pedestal gradients
PEP-18	Pedestal Physics	Rotation effects on type I ELMing H-mode in DIII-D and JT-60U
PEP-19	Pedestal Physics	Edge transport in RMP discharges in DIII-D and TEXTOR
DSOL-1	Divertor and SOL	Scaling of Type I ELM energy loss
DSOL-3	Divertor and SOL	Scaling of radial transport
DSOL-9	Divertor and SOL	¹³ C injection experiments to understand carbon migration
DSOL-12	Divertor and SOL	Oxygen wall cleaning
DSOL-13	Divertor and SOL	Deuterium codeposition with carbon in gaps of plasma facing components
MDC-1	MHD, disruption and ctrl	Disruption mitigation by massive gas jets
MDC-2	MHD, disruption and ctrl	Resistive wall mode experiments
MDC-12	MHD, disruption and ctrl	Non-resonant magnetic braking experiments
MDC-13	MHD, disruption and ctrl	Vertical stability physics & performance limits at high elongation
MDC-14	MHD, disruption and ctrl	Rotation effects on NTMs
SSO-1	Steady-state ops	Document performance boundaries for steady state q-profile discharges
SSO-5	Steady-state ops	Simulation and validation of ITER startup to achieve advanced scenarios
DIAG-1	Diagnostics	First mirror activity
DIAG-2	Diagnostics	Resolving the discrepancy between ECE and Thomson scattering at high T _e

Conducted under framework of large tokamak, poloidal divertor, and bi-lateral implementing agreements



DIII-D is a National Collaborative Program: Including Labs, Universities, Students, and Scientists

- Fast ion profile (**UCI**)
- IR cameras (**LLNL**)
- Fast ion collectors (**UCI**)
- SXR (**UCSD**)
- Filterscopes (**ORNL**)
- Scattering (**UCLA**)
- Vertical scanning probe (**UCSD, SNL**)
- Radial scanning probe (**UCSD, SNL**)
- Visible cameras (**LLNL**)
- Tile current array (**PPPL**)
- DISRAD (**UCSD**)
- SXR (**UCSD**)
- BES (**UW**)
- VUV cameras (**LLNL**)
- ASDEX gauges (**ORNL**)
- MSE (**LLNL**)
- Fast framing camera (**UCSD**)
- CECE (**UCLA**)
- ECE (**UT, UM**)
- Neutrons (**UCI**)
- Phase contrast imaging (**MIT**)



DIII-D is a Large, International Program



Active Collaborations 2008



- **92 institutions worldwide**
- **491 scientific authors**
 - GA: 135
 - Collab: 356
- **Students, post docs, and faculty from 41 universities**
 - 17 PhD students
 - 9 Post Docs

US Labs

ANL (Argonne, IL)
LANL (Los Alamos, NM)
LBNL (Berkeley, CA)
LLNL (Livermore, CA)
ORNL (Oak Ridge, TN)
PPPL (Princeton, NJ)
SNL (Sandia, NM)

Industries

ALITRON (CA)
Calabasas Creek (CA)
CompX (Del Mar, CA)
CPI (Palo Alto, CA)
Digital Finetec (Ventura, CA)
DRS (Dallas, TX)
DTI (Bedford, MA)
FAR-TECH, Inc. (San Diego, CA)
GA (San Diego, CA)
Lodestar (Boulder, CO)
SAIC (La Jolla, CA)
Spinner (Germany)
Tech-X (Boulder, CO)
Thermacore (Lancaster, PA)
TSI Research (Solana Beach, CA)

US Universities

Auburn (Auburn, Alabama)
Colorado School of Mines (Golden, CO)
Columbia (New York, NY)
Georgia Tech (Atlanta, GA)
Hampton (Hampton, VA)
Lehigh (Bethlehem, PA)
Maryland (College Park, MD)
Mesa College (San Diego, CA)
MIT (Cambridge, MA)
New York U. (New York, NY)
Palomar (San Marcos, CA)
Purdue U. (West Lafayette, IN)
SDSU (San Diego, CA)
Texas (Austin, TX)
UCB (Berkeley, CA)
UC Davis (Davis, CA)
UCI (Irvine, CA)
UCLA (Los Angeles, CA)
UCSD (San Diego, CA)
U. Arizona (Tucson, AZ)
U. New Mexico (Albuquerque, NM)
U. Oklahoma (Tulsa, OK)
U. Rochester (NY)
U. Utah (Salt Lake City, UT)
Washington (Seattle, WA)
Wisconsin (Madison, WI)

European Community

CEA (Cadarache, France)
CFN-IST (Lisbon, Portugal)
Chalmers U. (Göteborg, Sweden)
CIEMAT (Madrid, Spain)
Consorzio RFX (Padua, Italy)
CRPP (Lausanne, Switzerland)
EFDA (Belgium)
FOM (Utrecht, The Netherlands)
Frascati (Frascati, Lazio, Italy)
KFZ (Jülich, Germany)
Helsinki U. (Helsinki, Finland)
IPP-CNR (Italy)
IPP (Greifswald, Germany)
IST (Lisbon, Portugal)
ITER (Cadarache, France)
JET-EFDA (Culham, United Kingdom)
Kharkov IPT (Ukraine)
Max Planck (Garching, Germany)
U. Dusseldorf (Germany)
UKAEA (Culham, United Kingdom)
U. Naples (Italy)
U. Rome (Italy)
U. Strathclyde (Glasgow, Scotland)

Japan

JAEA (Naka, Ibaraki-ken, Japan)
Hiroshima U. (Japan)
NIFS (Toki, Gifu-ken, Japan)
Tsukuba U. (Tsukuba, Japan)

Russia

Ioffe (St. Petersburg)
Keldysh (Udmurtia, Moscow)
Kurchatov (Moscow)
Moscow State (Moscow)
St. Petersburg State Poly (St. Petersburg)
Triniti (Troitsk)
Inst. of Applied Physics (Nizhny Novgorod)

Other International

Australia National U. (Canberra, AU)
ASIPP (Hefei, China)
IPR (Gandhinagar, India)
NFRI (Daejeon, S. Korea)
Nat. Nucl. Ctr (Kurchatov City, Kazakhstan)
Pohang U. (S. Korea)
Seoul Nat. U. (S. Korea)
SWIP (Chengdu, China)
U. Alberta (Alberta, Canada)
U. Toronto (Toronto, Canada)

A Broad Range of Scientific Personnel Exchanges Enhance International Collaborations and Joint Experiments

2007–2008

To DIII-D	From DIII-D
Plasma Control System Development S.-H. Han (KSTAR) S.H. Seo (KSTAR) B. Xiao (EAST) Q. Yuan (EAST) J. Qian (EAST)	Resonant Magnetic Perturbation Studies K.-H. Finken (FZ-Julich) M. Jakabowski (FZ-Julich) M. Lehnens (FZ-Julich) B. Unterbert (FZ-Julich) O. Schmitz (FZ-Julich) H. Frerichs (FZ-Julich) D. Reiter (FZ-Julich) D. Harting (FZ-Julich) D. Schega (FZ-Julich) R. Buttery (UKAEA)
NTM Stabilization R. Buttery (UKAEA) F. Volpe (MPI Gesellschaft)	
Pedestal Studies C. Maggi (IPP-Garching)	Transport Physics L. Vermare (IPP-Garching)
AT Scenarios S. Ide (JAES)	Boundary Physics S. Brezinsek (IPP-Garching) A. Litnovsky (FZ-Jülich)
	ITB Physics and Real Time Control (JET) P. Gohil (GA)
	AT Scenarios (JET) T. Luce (GA) J. Ferron (GA) M. Murakami
	Ergodic Divertor Studies (TEXTOR) T. Evans (GA)
	Remote Participation on ELM Control Studies (JET) T. Evans (GA) P. Gohil (GA) R. Moyer (UCSD) T. Osborne (GA)
	Pedestal (JET) T. Leonard (GA) T. Osborne (GA)
	Divertor Hardware Development (EAST) M. Schaffer (GA)
	Neutral Beam Development (EAST) R. Callis (GA)
	Plasma Control System Development (EAST) D. Humphreys (GA) M. Walker (GA) J. Leuer (GA) G. Jackson (GA) D. Piglowski (GA) B. Penaflor (GA) A. Hyatt (GA)
	Plasma Control System Development (KSTAR) M. Walker (GA) D. Piglowski (GA) B. Penaflor (GA)
	ITER COD AC Design (ITER Cadarache) M. Walker (GA) D. Humphreys (GA)

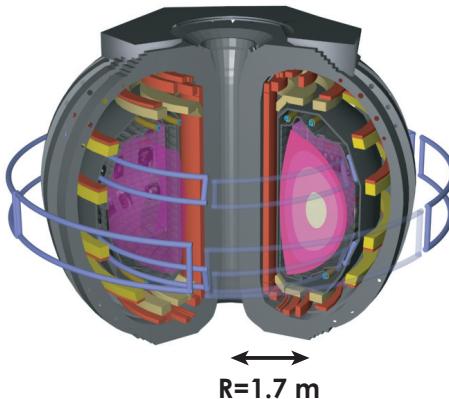
- 22 scientists visiting DIII-D to participate in experiments, with 25 DIII-D scientists visiting international partners

Coordination Among the Three US Fusion Facilities Contributes to Research Effectiveness and Excellence

Alcator C-Mod



DIII-D



NSTX



Joint Research areas:

- Pedestal
- Dimensionally similar discharges
- ICRF
- Intrinsic/spontaneous rotation
- Disruptions

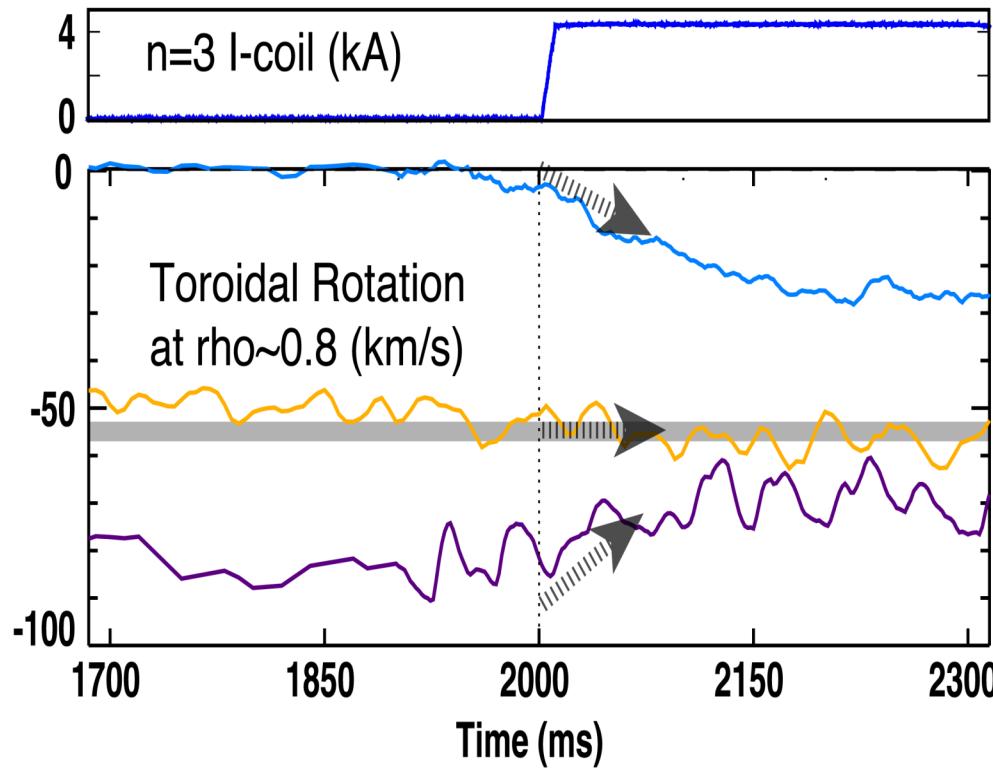
Joint Research areas:

- Pedestal
- Plasma control
- RMP ELM-control
- Fast ions
- Momentum transport
- RWM, NTM

- **Tokamak planning workshop, September 2007**
 - Five-year program plans from DIII-D, C-Mod, NSTX
 - Coordinated plans prepared prior to workshop and discussed
- **Fusion facilities coordinating committee**
 - Assists in the coordination of research on US facilities
 - Members: program directors, PAC chairs — Chair R. Hawryluk
- **Level 1 joint milestones for coordinated research**

Making Good Progress Towards FY08 Joint Facilities JOULE Milestone on Plasma Rotation

Evaluate the generation of plasma rotation and momentum transport, and assess the impact of plasma rotation on stability and confinement.



- The three facilities have planned experiments to address the milestone
 - Over 20% of the run time at each facility
 - First Quarter target achieved
- DIII-D experiments show $n=3$ perturbation causes acceleration at high β and low NBI torque (<0)
 - Consistent with NTV theory
 - Expect to complete 2nd quarter target on time

FY08 DIII-D Milestones Include the Support for JOULE Milestone

- **165** – Evaluate the use of non-axisymmetric magnetic fields for ELM control in ITER relevant plasmas
- **166** – Explore ITER start-up scenario issues in DIII-D using shape evolution that reproduces the ITER scenario, scaled to DIII-D size with appropriate current ramp rates
- **FY08 Joint Facility JOULE Milestone** – Conduct experiments on major fusion facilities leading toward the predictive capability for burning plasmas and configuration optimization. In FY08, FES will evaluate the generation of plasma rotation and momentum transport, and assess the impact of plasma rotation on stability and confinement.
- **167** – Evaluate momentum transport, intrinsic rotation and the impact of the torque input and rotation on the L-H transition, turbulent transport, and macro stability. Supports JOULE milestone

Strong Interest Expressed for Participating in DIII-D Research

Area	Proposals Received
ITER Demonstration Discharges Task Force	17
Rotation Physics Task Force	62
ELM Control and Pedestal Physics Task Force	80
Steady-State Integration Group	63
Integrated Modeling Group	3
ITER Physics Group	67
Plasma Control and Operations Group	26
Fusion Science Group	153
Total Proposals	471

- **Three-day Research Opportunities Forum in October 2007**
 - 471 proposal submissions
 - 138 from universities; 23 from international collaborators

DIII-D PAC Recognizes the DIII-D Contribution to ITER R&D Needs and Potential for Future Advances

Research Supporting ITER R&D

“The PAC commends DIII-D for responding to immediate ITER needs and also for proposing to contribute strongly to intermediate and longer-term ITER design needs”

Future Research Plans (FY09 and Beyond)

“The PAC feels that full implementation of the proposed neutral beam current drive and electron cyclotron current drive would put DIII-D in the lead for the development of advanced tokamak physics”

Summary of Papers and High Visibility Presentations of the DIII-D and GA Theory Programs in FY07-08

- **9 APS-DPP invited presentations**
- **1 APS-DPP review presentation**
- **3 EPS invited presentations**
- **Invited talk at the Chaos, Complexity and Transport Workshop**
- **Invited talk at Festival de Théorie**
- **Published over 30 refereed journal articles**



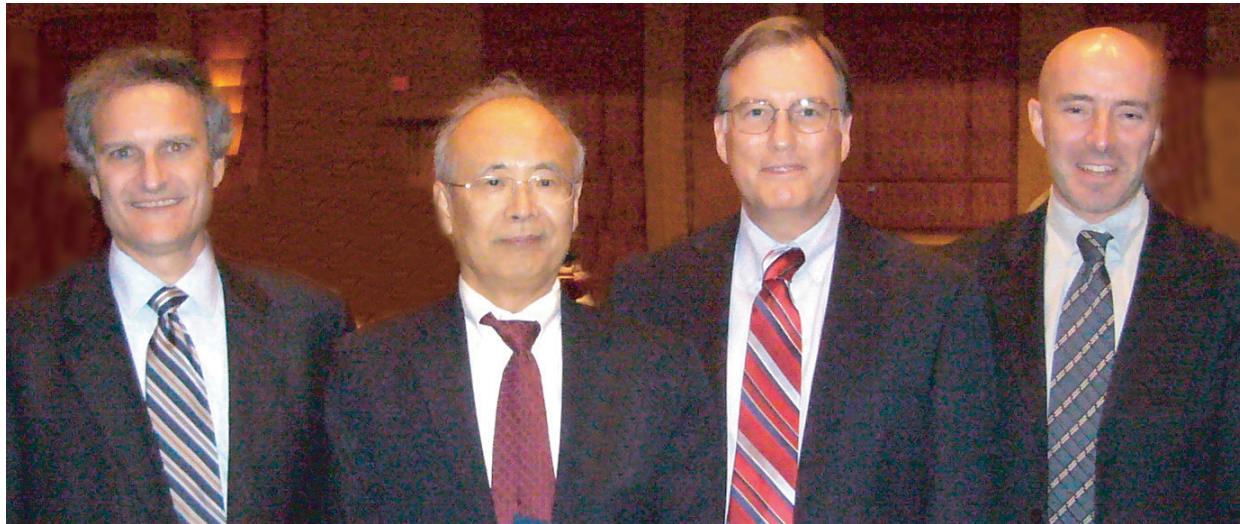
DIII-D Program Recognition in FY07-08

- 2007 APS John Dawson Award for Excellence in Plasma Physics Research to Dr. Andrea Garofalo (Columbia U.), Dr. Gerald Navratil (Columbia U.), Dr. Michio Okabayashi (PPPL), and Dr. Edward Strait (GA)
- Dr. Craig Petty (GA) was named a Fellow of the American Physical Society.
- Dr. Vincent S. Chan (GA) served as Chairman of the Division of Plasma Physics of the American Physical Society.
- Dr. Steven L. Allen (LLNL) served as the Secretary-Treasurer of the Division of Plasma Physics of the American Physical Society.
- Dr. Keith H. Burrell served as the Chair of the Transport Task Force.
- Dr. Charles M. Greenfield is the Deputy Director of the US Burning Plasma Organization.
- Dr. William Heidbrink (UC Irvine) gave a review presentation at the APS-DPP 2007 meeting on “Instabilities Driven by Energetic Particles in Magnetized Plasmas” which highlighted many DIII-D experimental results.



Craig Petty (GA)

2007 John Dawson Award for Excellence in Plasma Physics Research to DIII-D Scientists



*Gerald Navratil Michio Okabayashi Edward Strait Andrea Garofalo
(Columbia) (PPPL) (GA) (Columbia)*

“For experiments that demonstrated the stabilization of the resistive wall mode and sustained operation of a tokamak above the conventional free boundary stability limit.”

Illustrates highly collaborative character of the DIII-D Program

DIII-D Program Plan Contributes to Many of the Scientific Issues Identified by the FESAC "Planning" Panel

- **Scientific and technical issues to address before proceeding to DEMO**

Issue	Addressed in DIII-D
Theme A. Creating predictable high-performance steady-state plasmas	
1. Measurement	✓
2. Integrator of high-performance, steady-state, burning plasmas	✓
3. Validated theory and predictive modeling	✓
4. Control	✓
5. Off-normal plasma events	✓
6. Plasma modification by auxiliary systems	✓
7. Magnets	✓
Theme B. Taming the plasma material interface	
8. Plasma-wall interactions	✓
9. Plasma facing components	
10. RF antennas, launching structures and other internal components	✓
Theme C. Harnessing fusion power	
11. Fusion fuel cycle	
12. Power extraction	
13. Materials science in the fusion environment	
14. Safety: Demonstrate the safety and environmental potential of fusion power	
15. Reliability, availability, maintainability, inspectability	

- **From: FESAC panel report on "Priorities, Gaps and Opportunities: Towards A Long-Range Strategic Plan for Magnetic Fusion Energy"**

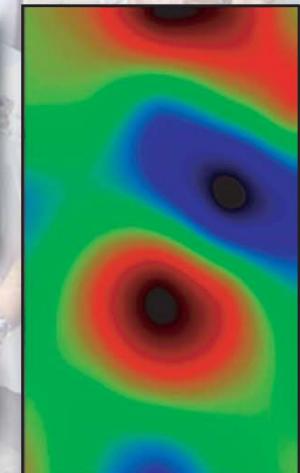
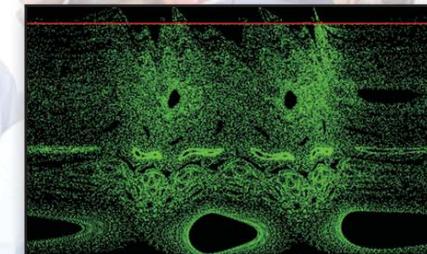
Outline of the DIII-D Presentations

- | | | |
|---|---------------------|------------|
| • DIII-D Program Overview | D.N. Hill (LLNL) | 15 minutes |
| • DIII-D Research Plans | M.R. Wade (GA) | 40 minutes |
| • DIII-D Program Budgets
and Schedules | T.S. Taylor (GA) | 15 minutes |
| • GA Institutional Issues | R.D. Stambaugh (GA) | 15 minutes |
| • Community Discussion | | 15 minutes |

DIII-D Research Plan

by
M.R. Wade

Presented at
FY10 Budget Planning Meeting
Office of Fusion Energy Science
Washington, DC



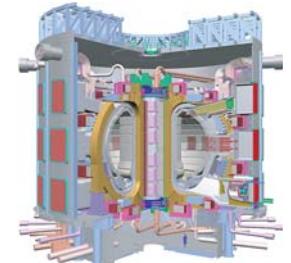
March 11-12, 2008

DIII-D Mission: Establish the Scientific Basis for the Optimization of the Tokamak Approach to Fusion Energy Production

Near-term research objectives:

- ITER support: Enable the success of ITER by providing physics solutions to key issues
- Advanced tokamak: Establish the physics basis for steady-state high performance operation for ITER and beyond
- Science: Advance the fundamental understanding of fusion plasmas along a broad front

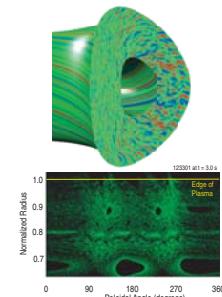
Fusion Demonstration



Attractive Energy Source



Scientific Understanding

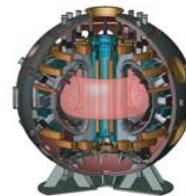


DIII-D Program Plan Will Contribute to the Basis for Several Next-step Fusion Projects Worldwide

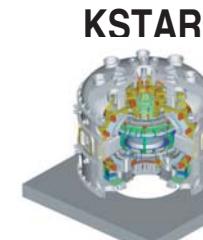
- Enable the success and improve the scientific output of ITER
- Develop physics basis of steady-state tokamak operation for demonstration in super conducting devices
- Inform decision on the next step in fusion energy development in U.S.
- Validate models to be used for fusion plasma simulation



ITER



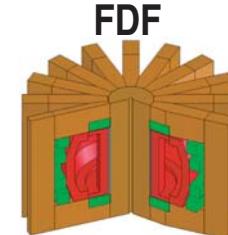
JT-60SA



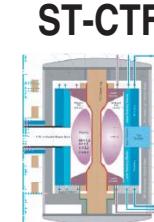
KSTAR



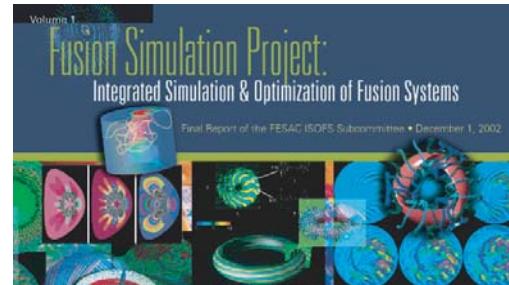
EAST



FDF



ST-CTF

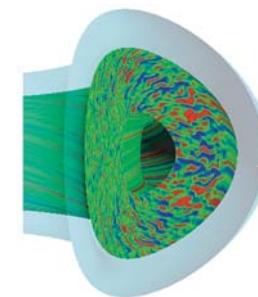


Five-year Plan Strategy Capitalizes on DIII-D's Strengths of Excellent Fusion Science Research, State-of-the Art Control, and Scenario Integration

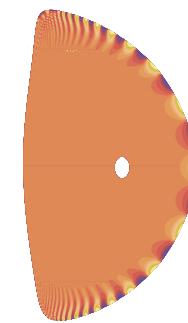
Strategy:

- Develop detailed insight into complex physical phenomena
- Translate knowledge into state-of-the-art model-based control
- Utilize control capabilities to develop integrated scenarios for ITER and future devices

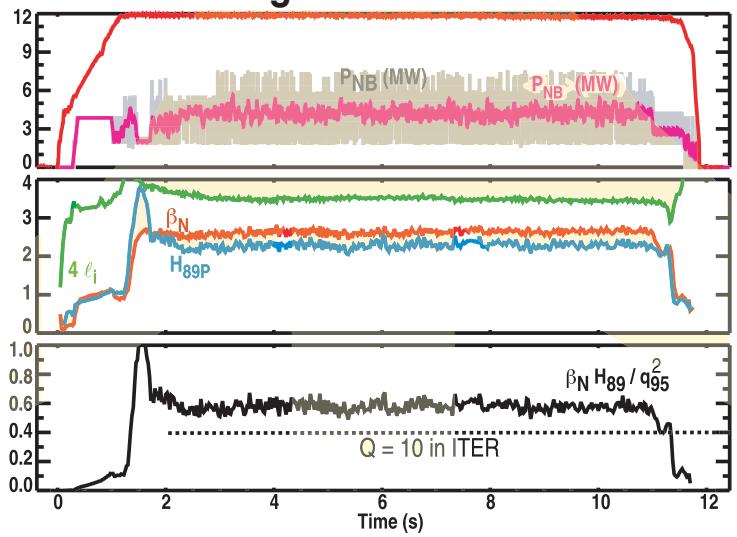
Turbulence



MHD

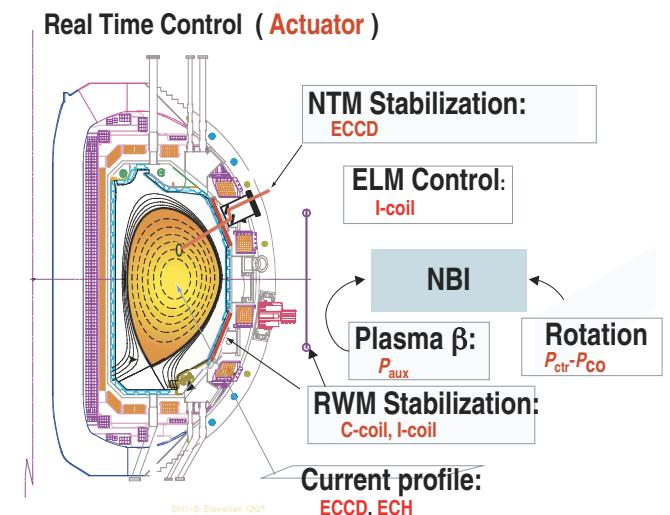


Integrated Scenarios



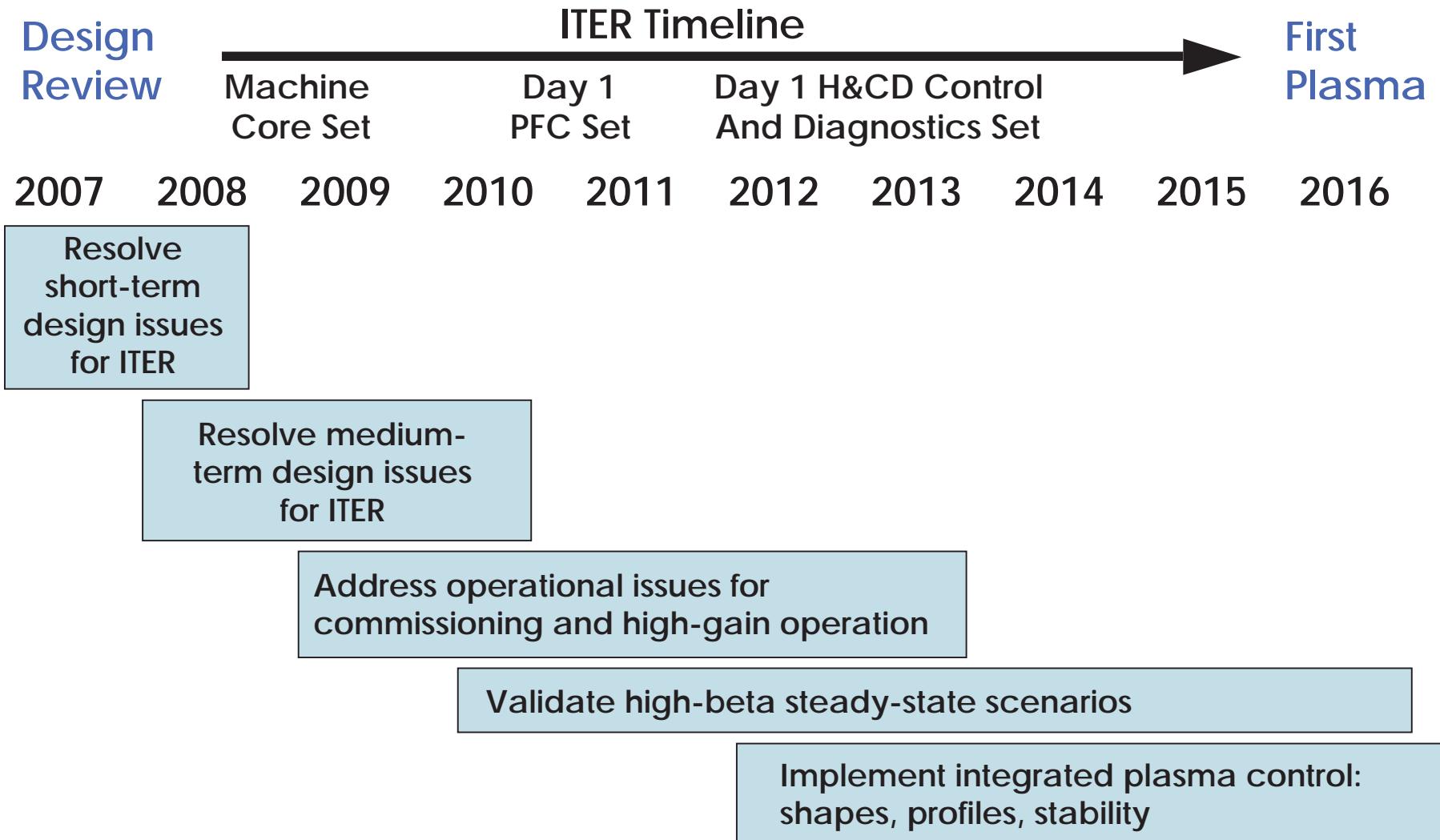
Facility Enhancements Will Enable a Wide Range of Research Activities

- Significant diagnostic improvements enhance scientific research
 - Core, edge, divertor
 - Profiles, turbulence
- Enhanced capabilities for implementing model-based plasma control
- Increased H & CD flexibility for science research and scenario development
 - Increase NBI power to 20 MW
 - Provide 10MW of off-axis NBCD
 - Increase ECH/ECCD power to 9 MW



Support for ITER is the Major Focus of DIII-D Research

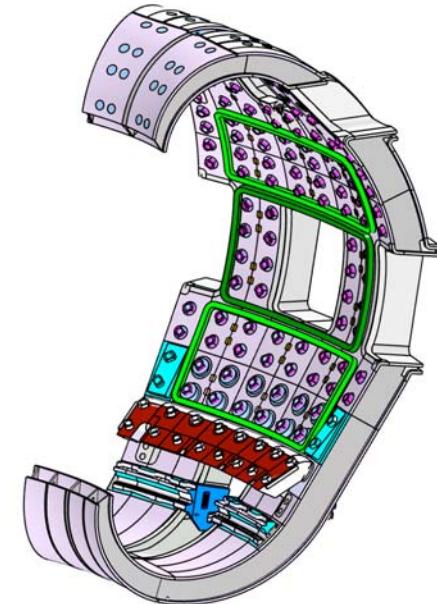
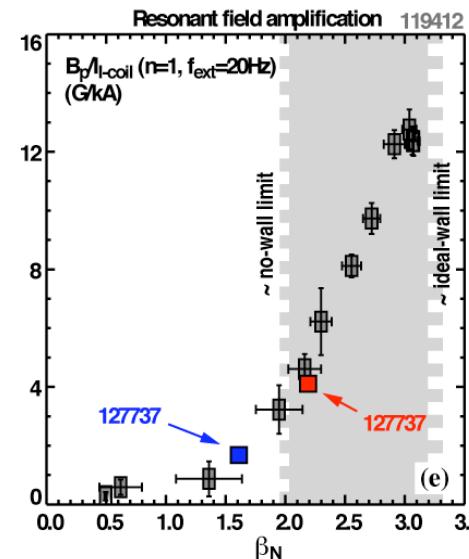
- Focus of program will evolve with ITER's changing needs



Final ITER Design is Being Heavily Influenced by DIII-D Contributions

Recent memos to ITER IO:

- Recent DIII-D ELM Control Results Using an $n=3$ RMP from a Single Row of Coils
 - T. Evans, M. Fenstermacher, M. Schaffer
- Frequency of the EC system for plasma startup in ITER
 - T. Luce
- ITER Scenario Demonstration Discharges in DIII-D
 - T. Luce, T. Osborne, E. Doyle
- Requirements for acceptable error field correction in ITER
 - A. Garofalo, E. Strait



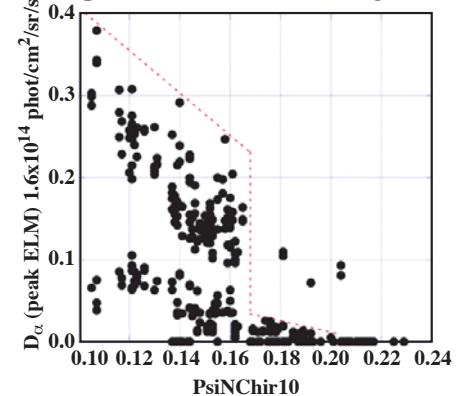
Work in progress:

- Vertical stability of ITER plasmas
- Requirements on ITER poloidal field systems
- Disruption loads and mitigation system requirements

Near-Term ITER Program Focused on Resolving Key Issues for Built-In Components

- **ELM and RWM control:**
 - Establish physics basis for choice of ELM and RWM control coils in ITER
- **Hydrogenic retention:**
 - Evaluate techniques for mitigating/removing tritium from carbon PFCs in ITER
- **Disruption mitigation:**
 - Establish physics basis for avoidance and mitigation of disruptions in ITER
(Major challenge: runaway electron suppression)
- **NTM control:**
 - Validate requirements for ECCD for suppression of NTMs

ELM Size vs Width of Stochastic Region Produced by RMP



Non-Heated Mirror Heated Mirror

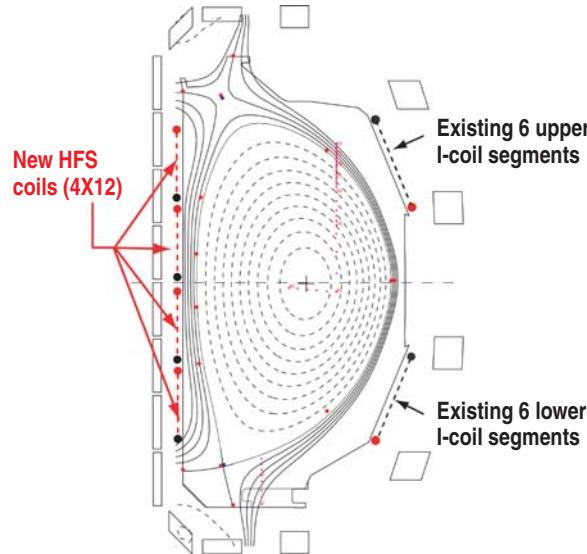
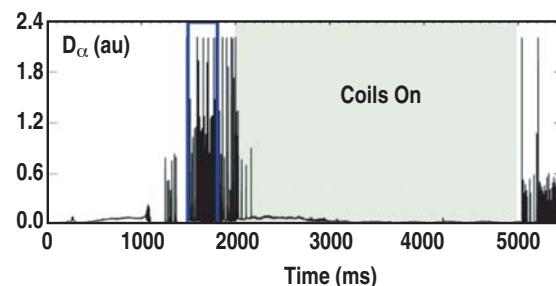


Medusa Valve



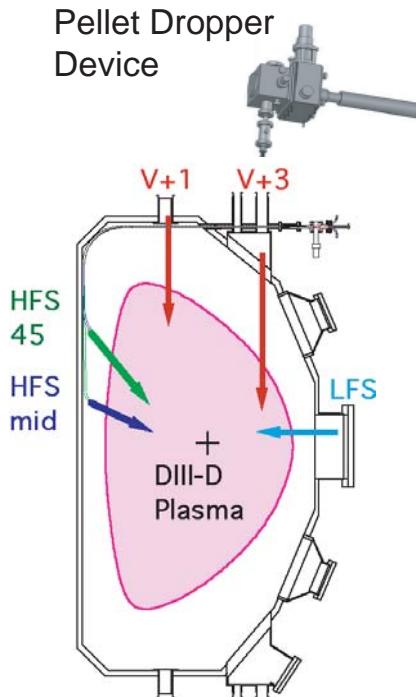
ELM Control Studies Will Focus on Identifying Best Means for ELM Mitigation in ITER

RMP ELM Suppression



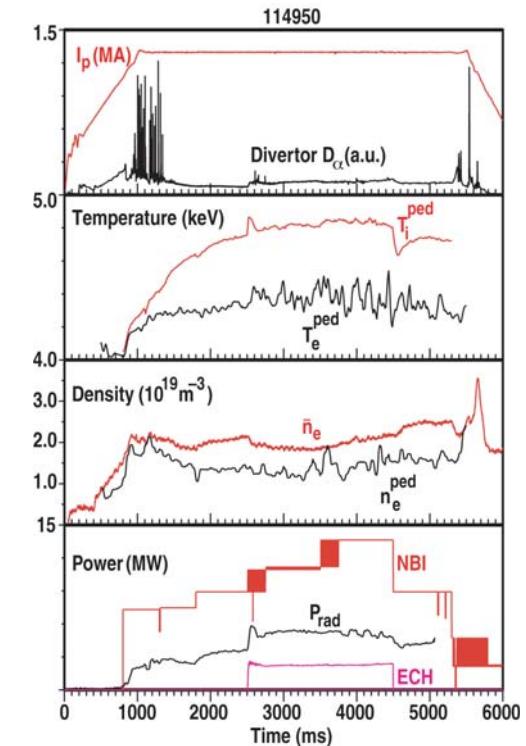
- Determine physics mechanism(s) leading to ELM suppression

Pellet Pacing



- Characterize penetration requirements
- Assess impact of successful ELM mitigation on pedestal

QH-mode



- Identify mechanisms responsible for EHO
- Expand operating space to balanced and co-NBI

The Proposed Inner Wall RMP Coil Will Enhance Physics Understanding of ELM Suppression

- Enables physics opportunities (short list):

- Increased flexibility in mode spectrum
- Isolate resonant and non-resonant effects
- Differentiate stochasticity from peeling/ballooning stability modifications
- ELM suppression at low q_{95}

2008:

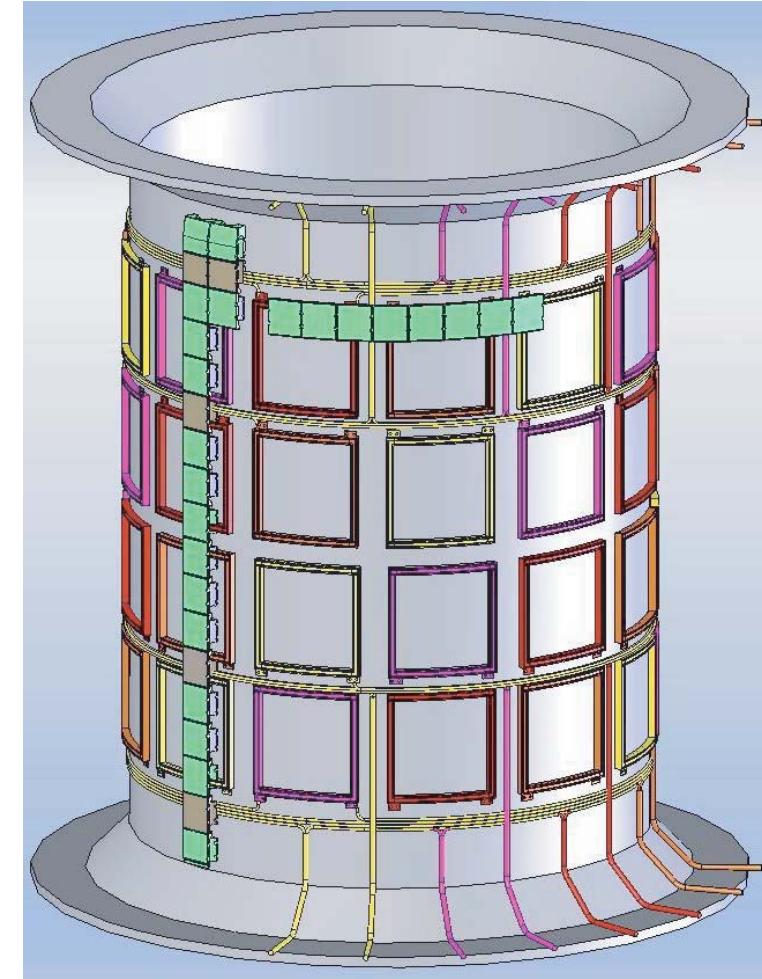
- Assess mechanisms for enhanced particle transport
- Improve understanding of ELM suppression window

2009:

- Design Inner Wall RMP coils
- Assess ELM pacing by pellets

2010: (Incremental)

- Install Inner Wall RMP coils



DIII-D Research in 2008-10 Will Provide Timely Input on a Wide Range of ITER Design and Early Operation Issues

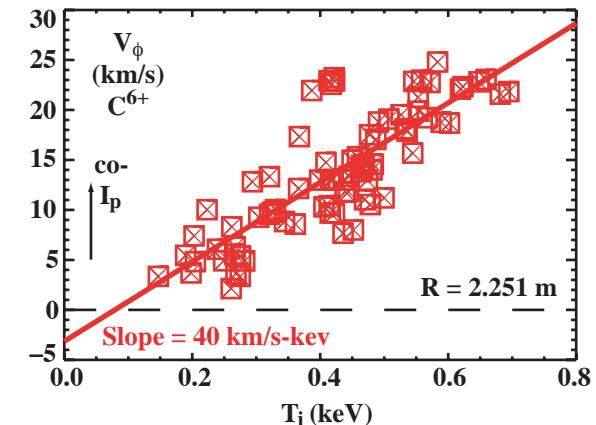
	2008	2009	2010	2011	2012
RMP ELM Control	Improve RMP physics basis	Evaluate impact of rotation	Install Inner Wall RMP coil	Test theories of ELM suppression	Demonstrate ELM suppression in ITER Demo Discharges
Other ELM Control	Test EHO theories (QH)	Pellet ELM-pacing	Establish link between EHO and RMP	Test ITER pellet injector prototype	
Disruptions	Compare mitigation with models	Evaluate alternative gas delivery systems	Real-Time Stability Control	Demonstrate integrated fault protection	
NTM Stabilization	Test ECCD Modulation	Control 2/1 NTM at ITER-relevant rotation	Simultaneous 2/1 and 3/2 control	Real-Time ECCD Steering	
Tritium Retention	Evaluate/implement O2 bake	Hydrogenic retention in main wall	Co-deposition with heated walls		
Error Fields	Plasma response at high beta	Evaluate correction strategies for ITER	Develop algorithms for multi-mode correction		
Startup, Vertical Stability	Evaluate proposed ITER startup scenarios	Validate models for ITER shape and position control	Simulate ITER operation with imposed control limitations		

Intrinsic Rotation/Momentum Transport Studies Are Developing an Improved Prediction for Rotation in ITER

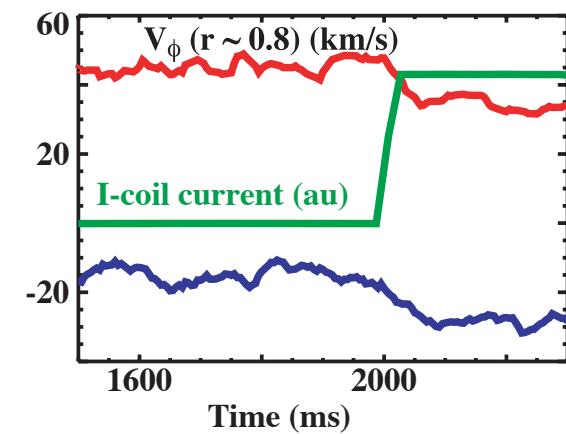
- Ongoing studies are focused on key issues:
 - Identifying mechanisms for intrinsic rotation
 - Assessing impact of non-resonant 3-D fields
 - Characterizing momentum transport over a wide range of conditions

- 2008:
- Differentiate roles of ExB shear and magnetic shear in transport barrier formation
 - Test NTV theory over wide range of conditions
 - Test theories for intrinsic rotation
 - Characterize roles of diffusive versus convective momentum transport
- 2009:
- Begin assessment of turbulence-driven momentum transport models
 - Poloidal rotation studies
- 2010:
- Develop ITER scenarios at zero torque input

Pedestal Intrinsic Rotation Consistent with Orbit Loss Theory



Rotation Response to Applied $n=3$ Field Consistent with NTV Theory



Plan Aims to Develop an Improved Physics Basis for ITER Based on Model Validation and Scenario Demonstration

	2008	2009	2010	2011	2012
Physics Basis	Improve predictive capabilities for rotation, pedestal	Evaluate transport with $Te = Ti$	Hydrogenic Retention		
Model Validation		Test predictive models of transport, stability, energetic particles	Refine and validate predictive models	Start testing of Prototype ITER simulator	
Control Algorithms	Complete test of model-based shape control	Demonstrate routine NTM, RWM, ELM control		Real-time control near stability limits	
Scenario Development					
Baseline Scenario	Demonstrate proposed ITER scenarios	Integrated performance with radiative divertor operation	Add ELM Suppression	Demonstrate scenarios at low rotation, $Te=Ti$, rad. div., ELM supp.	
Hybrid Scenario					
Advanced Tokamak		Evaluate compatibility with ITER hardware set		Develop access technique with ITER Day 1 H&CD Set	

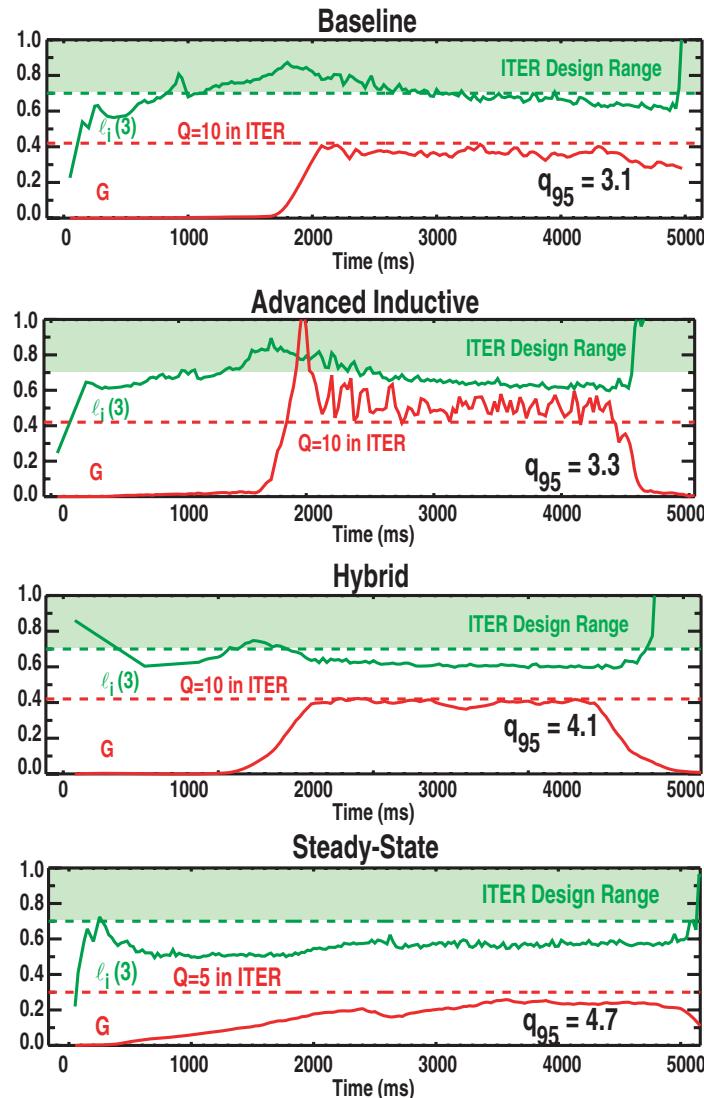
- **Ultimate goal is to maximize the scientific output of ITER by establishing a comprehensive physics basis prior to the start of ITER operation**

Proposed Facility Enhancements Will Position DIII-D As A Prototype for ITER Operation

	ITER	DIII-D Plan
Heating	33 MW NBI 20 MW EC 20 MW FW	20 MW NBI 9 MW EC 6 MW FW
Current Drive	Off-axis NBCD Off-axis ECCD	10 MW Off-axis NBCD 12 MW Off-axis ECCD
Fueling	Pellet Injection	Gas, Pellet Injection
Instability Control	ELMs: RMP Coils, Pellets NTMs: ECCD RWMs: Internal/External Coils	ELMs: RMP Coils, Pellets NTMs: ECCD RWMs: Internal/External Coils
Plasma Control	Digital, Model-Based	Digital, Model-Based
Diagnostics	Optimized for Mission	Comprehensive (Core, Pedestal, SOL, Turbulence)

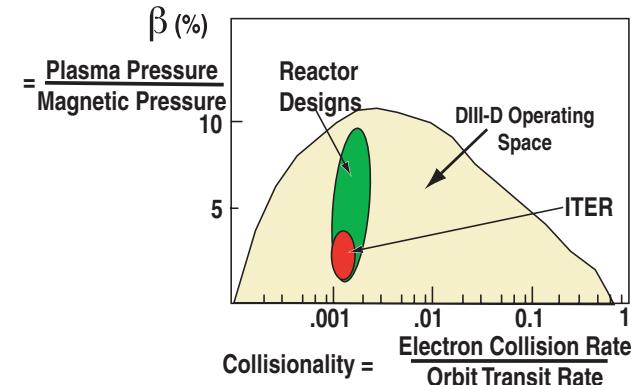
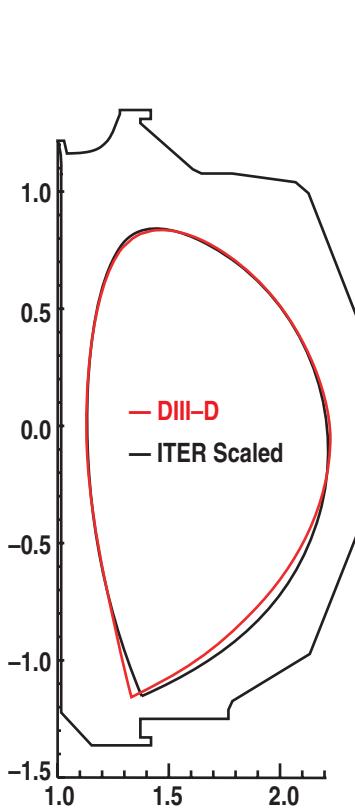
DIII-D's Similarity to ITER Enables Direct Development of a Detailed Physics Basis for ITER

- DIII-D can simulate ITER scenarios ... in the ITER shape and aspect ratio ... at ITER relevant conditions



in the ITER shape
and aspect ratio ...

at ITER relevant conditions



- In addition, DIII-D can reproduce key ITER performance constraints
 - $T_i \approx T_e$
 - Low rotation
 - High n_e/n_{GW}

DIII-D Research Will Provide Key Information for Decisions on Next-step Options Based on Steady-State Operation

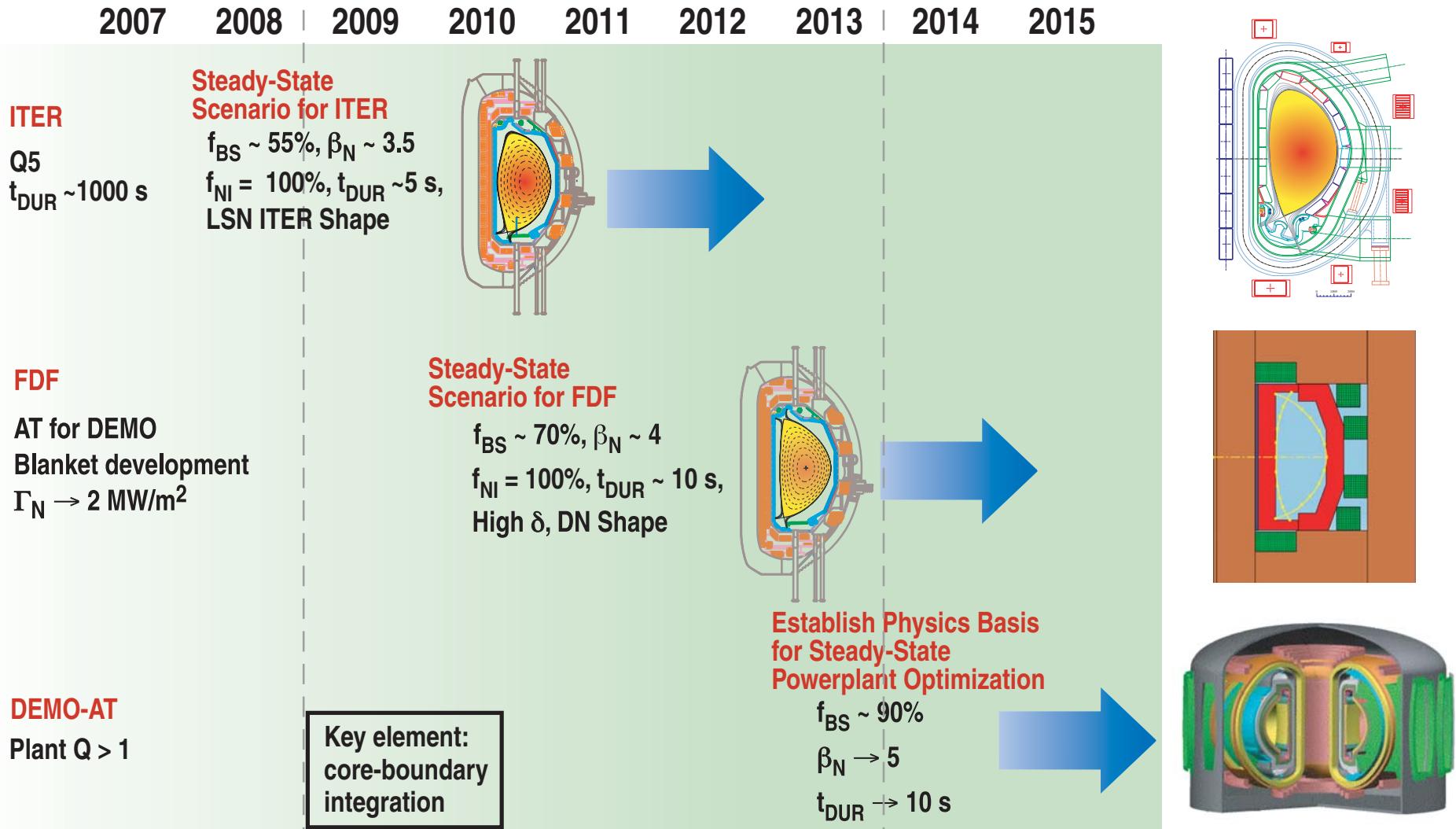
Greenwald Panel

- Demonstration of sustained high β ,
fully non-inductive operation
 - central to many next-step devices
(FDF, ST-CTF, NHTX)

- Improved physics understanding of methods
to control heat flux
 - First step towards solving materials issue for
high power density devices (ST-CTF, NHTX)

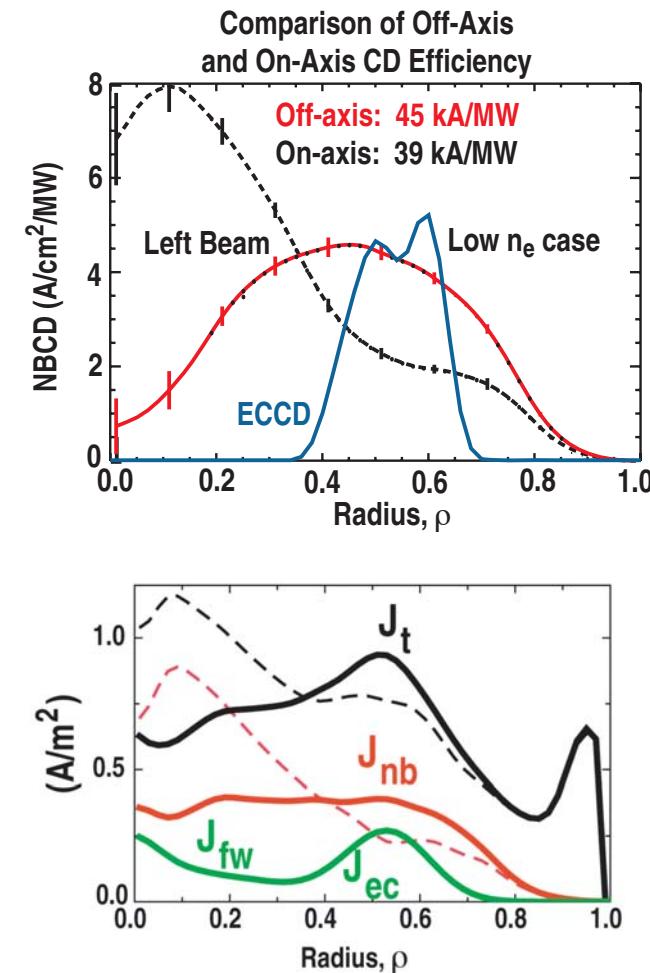
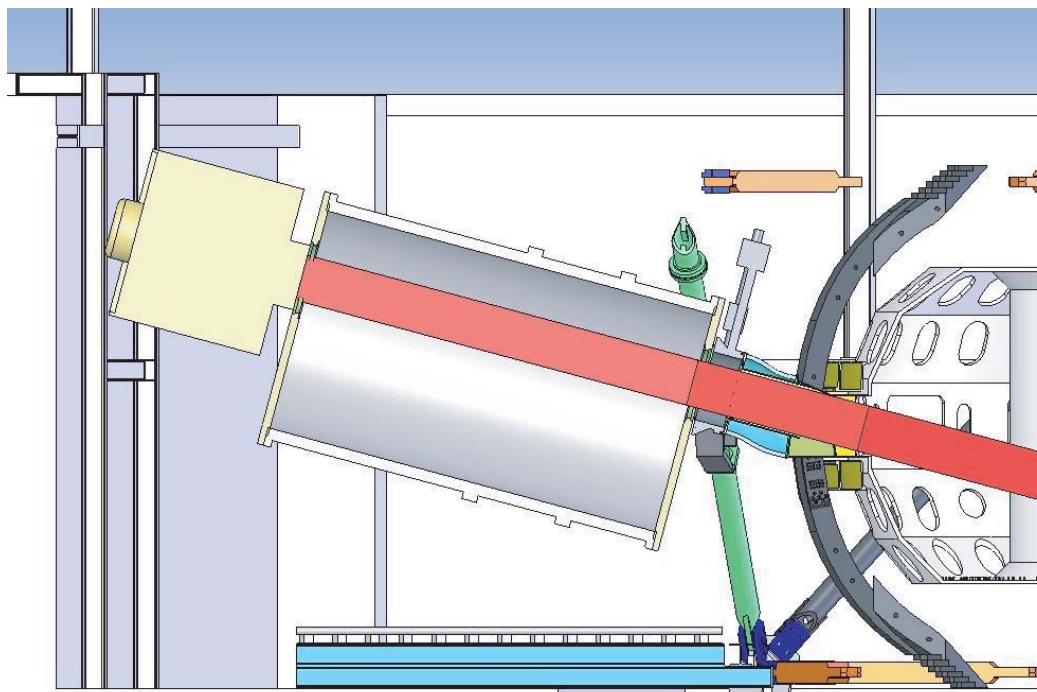
- Improved physics basis for extrapolations
 - Essential in design of next-step options (All)

Steady-state Scenario Development is Staged to Successively Achieve the Performance Requirement of Future Devices



Key Component of Research Plan is to Provide Required Off-axis Current Drive for Sustained High Performance

- Planned enhancements:
 - Upgrade of ECCD system to 9 MW
 - Off-axis neutral beam (10 MW)
- Capability enables high β Operation with broad current profile



Utility of High Power ECCD for Tearing Mode Avoidance in High β Discharges Has Been Demonstrated

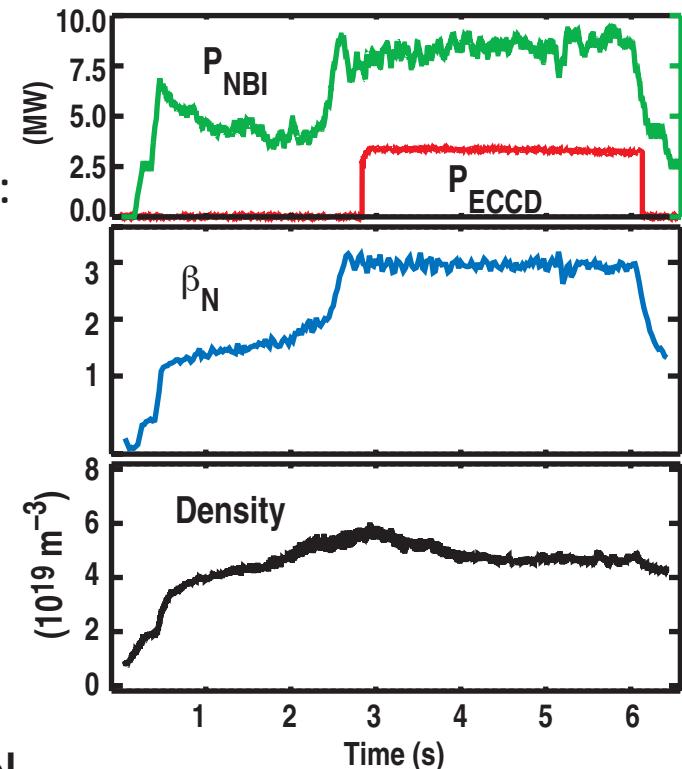
- Broadening of current profile with 3 MW of off-axis ECCD enables 3 s operation without NTMs at the no-wall limit
- High power EC has many other applications (e.g.):
 - $T_e \rightarrow T_i$ in advanced regimes
 - Validation of far off-axis ECCD theory
 - Probing of turbulence associated with electron transport

Examples of use from research plan:

2008: Discriminate ITG from TEM turbulence

2009: Assess ECCD modulation for 2/1 NTM control

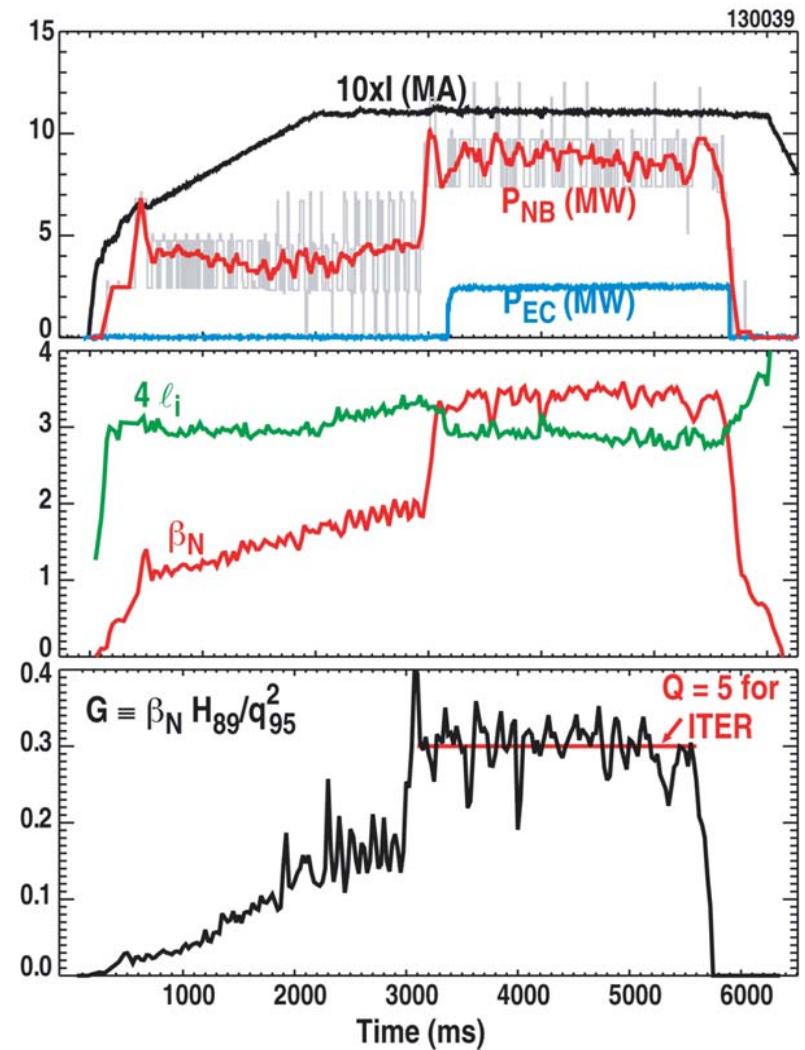
2010: Evaluate candidate ITER scenarios with $T_e = T_i$



Steady-State Research Will Improve the Physics Basis for Implementation in ITER and Future Devices

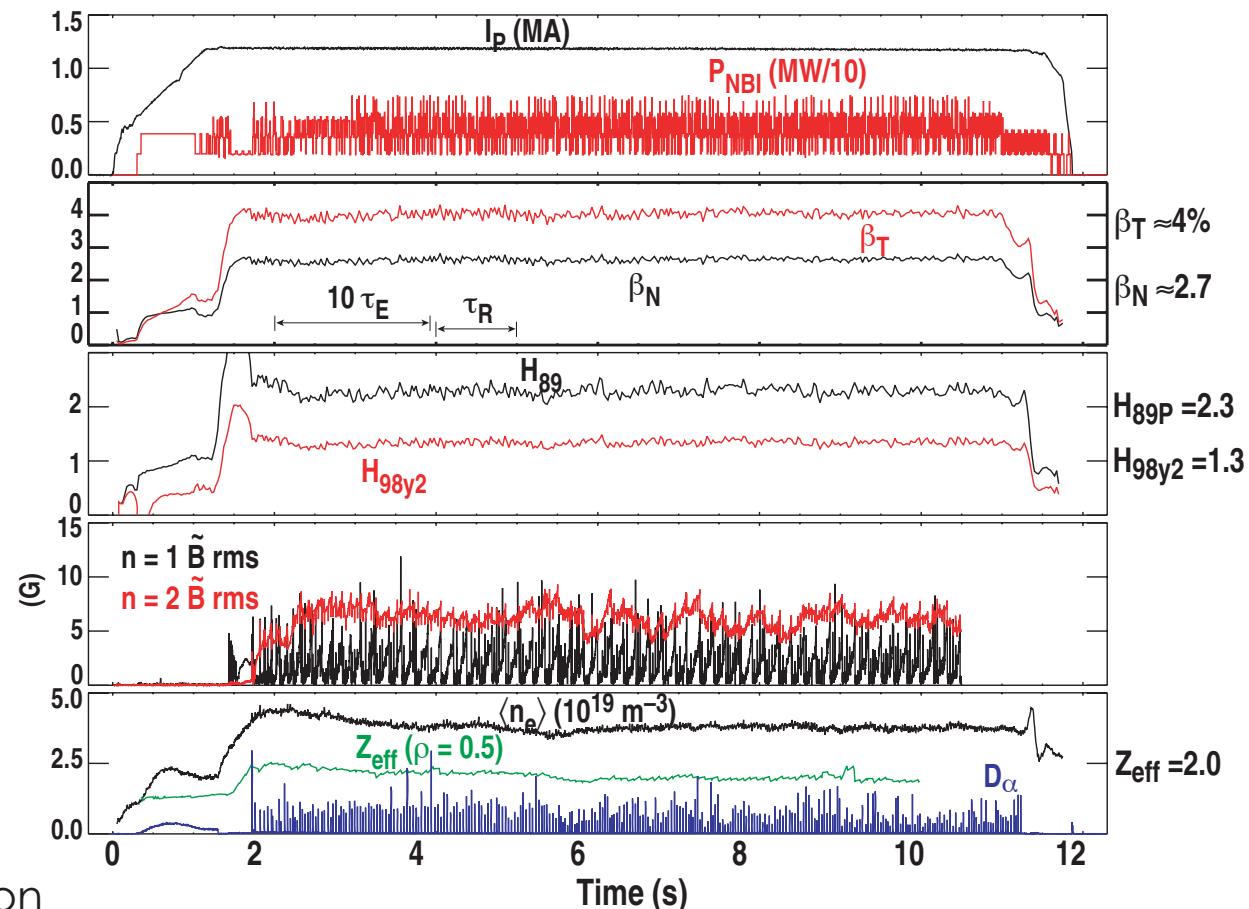
- Stationary performance consistent with Q=5 steady-state operation of ITER has been achieved
- Fully noninductive operation at high β for $3 \tau_E$, ($0.3 \tau_R$)

- 2008:
- Target q profile control
 - Stability dependence on shape and q
- 2009:
- Fully non-inductive demo
 - RWM stabilization at low rotation
- 2010:
- $\beta_N > 4$ exploration (20 MW NBI)
 - $n > 1$ RWM stabilization



Hybrid/Advanced Inductive Research Will Validate Regimes for Use in ITER

- Stationary high performance has been demonstrated at $q_{95} = 3$ and $q_{95} = 4$ for many resistive times
- First experiments assessing transport at low rotation and $T_e \rightarrow T_i$ conducted
 - 2008:
 - Radiative divertor
 - Stability limits
 - 2009:
 - ELM suppression
 - ρ_* scaling
 - 2010:
 - Transport with $T_e = T_i$
 - Combine radiative divertor & ELM suppression



Proposed Hardware Upgrades Are Aimed at Providing Capability to Demonstrate $\beta_N \sim 5$ for Extended Duration

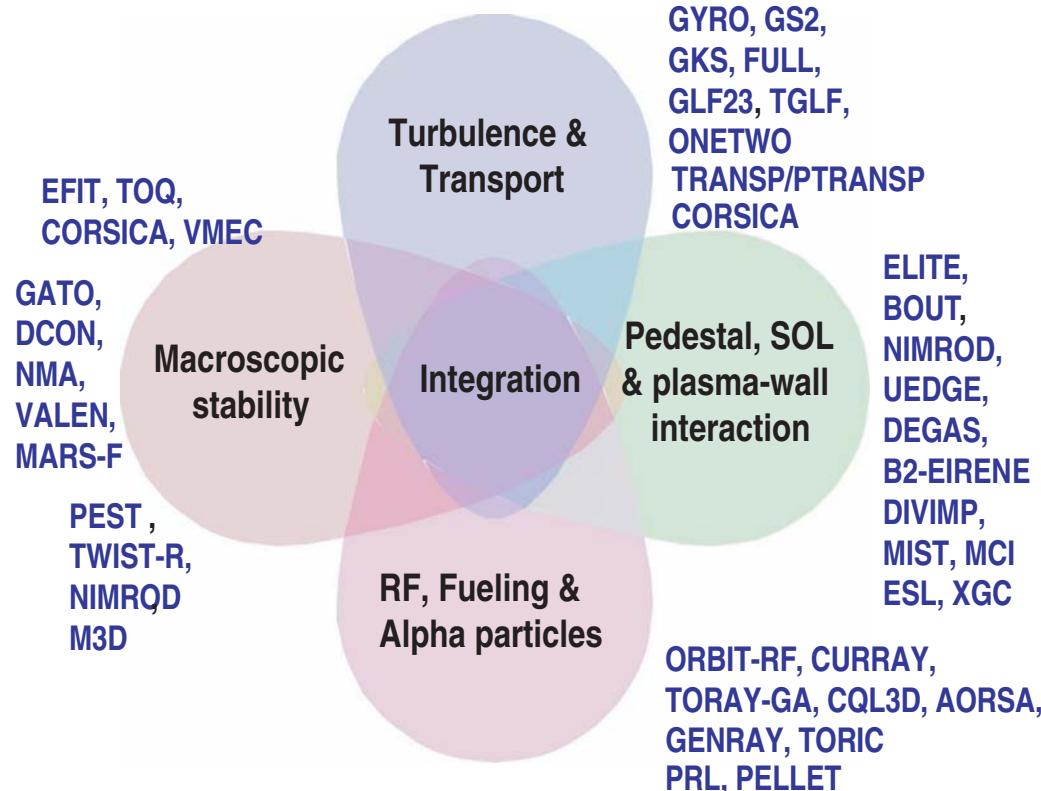
	2007	2008	2009	2010	2011	2012	2013	2014
Heating & CD		NB: 12.5 MW co, 5 MW ctr	+2.5 MW co		5 MW Off-Axis		10 MW Off-axis	
		EC: 4 MW	6 MW				9 MW	
		FW: 3 MW			new antenna			
Tools					Inner Wall RMP			
ITER $Q \geq 5$ $t_{DUR} \sim 1000$ s		Demonstrate $\beta_N > 3$, $f_{NI} = 1$ for $> \tau_R$	Evaluate scenario at $T_e = T_i$, low torque input		Evaluate potential boundary solutions			
FDF		Shape, bootstrap current optimization	Demonstrate $\beta_N = 4$, $f_{NI} = 1$ for $> \tau_R$				Integrate boundary solution	
DEMO-AT Plant $Q > 1$		Transient exploration of routes to $\beta_N \rightarrow 5$		Physics basis for RWM stabilization at low rotation		Demonstrate $\beta_N \rightarrow 5$, for $> 5 \tau_E$		
Edge Integration	Radiative Divertor	ELM suppression	Evaluate 3D fields for heat flux reduction					

DIII-D is Well Equipped to Lead Fusion Energy Research in a New Era of Detailed Comparisons of Experiment and Theory

- Previous 5 years marked by tremendous advances in measurement and simulation capability worldwide
- Recent investments have positioned DIII-D as a powerful scientific instrument for validating complex simulation codes
 - Tools now available to control key plasma parameters
 - Torque control (Ω_{tor} , ExB shear)
 - Significant Electron heating ($T_e \rightarrow T_i$)
 - Excellent density control (ν^*)
 - Extensive diagnostic set
 - Core Profiles (Kinetic, Current, Fast Ion)
 - Fluctuation measurements over a large spatial range ($k=1-40 \text{ cm}^{-1}$)
 - SOL/divertor properties (flow, heat/particle flux, DiMES)

Near-Term Activities Will Focus on Validating State-of-the-Art Theoretical Models

2008: GYRO: core turbulence
TGLF: pedestal transport



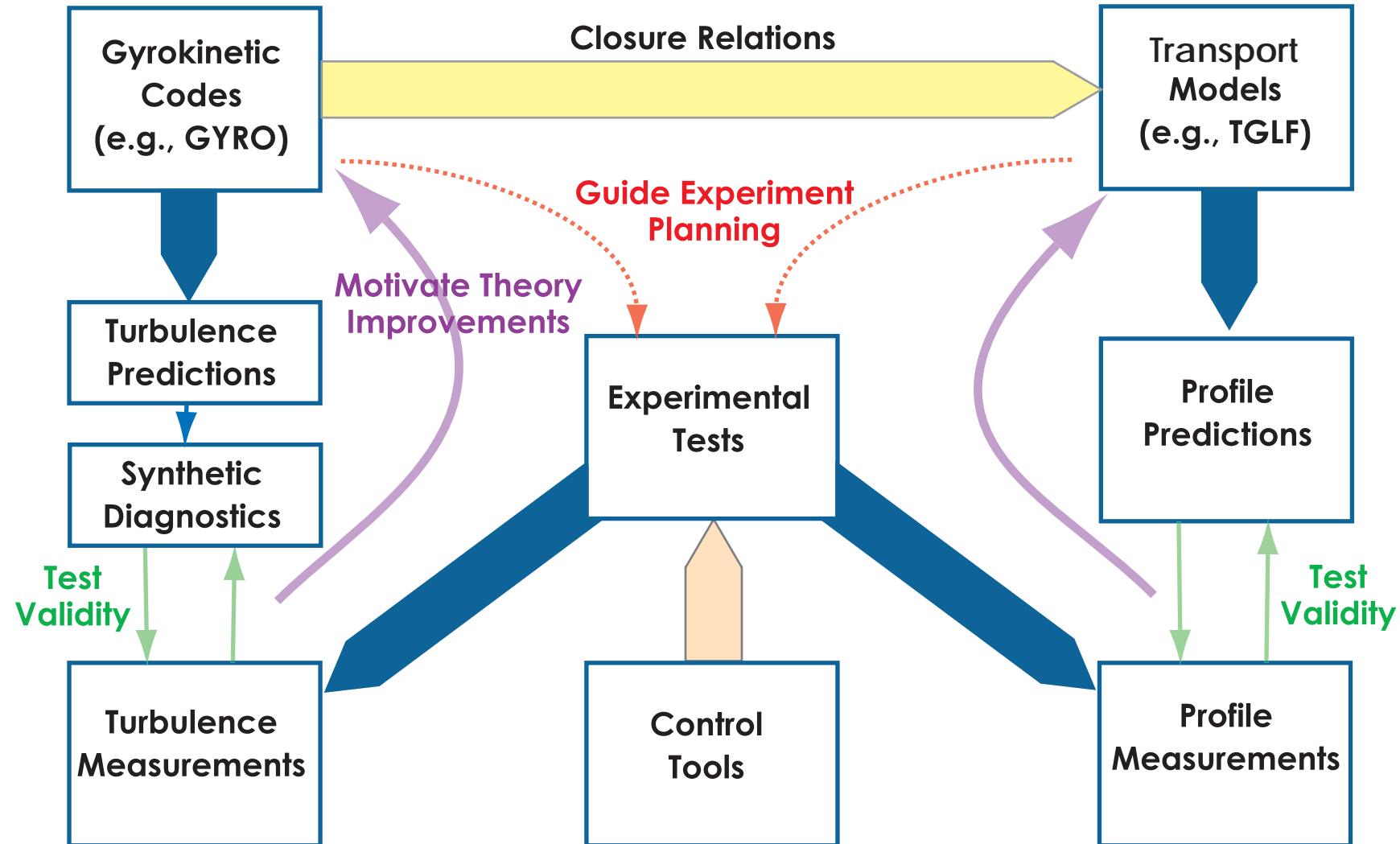
2009: BOUT: Edge turbulence
NOVA-K/ORBIT: fast ion transport by AEs

2010: NIMROD: Convective cells with RMP

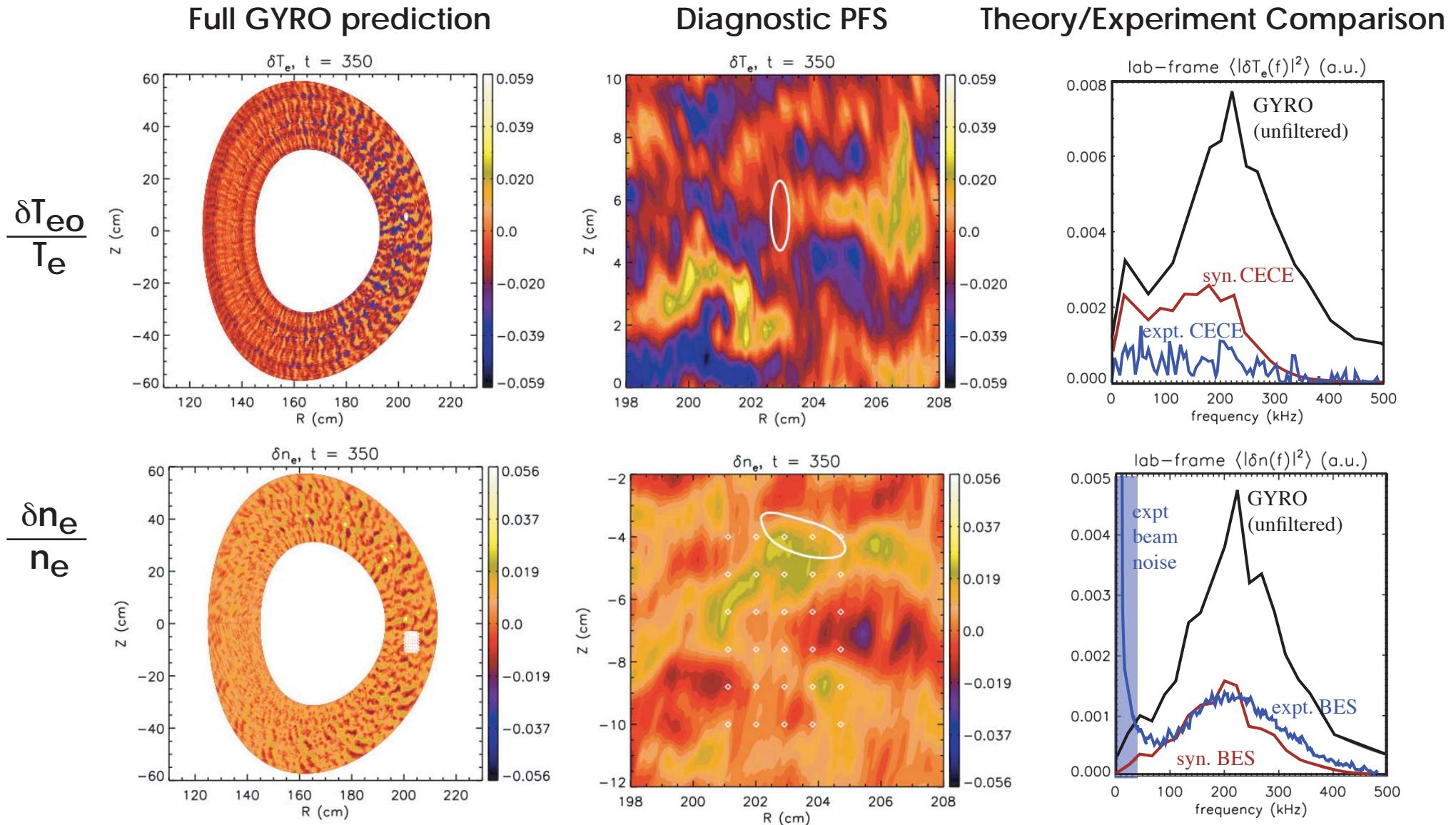
- Longer term activities
 - Validate models of interactions at multiple spatial scales
 - Integrate models into fully predictive code for use on ITER, FDF, ...

Validation Plan Requires Iterative Improvements of Theory, Modeling, and Experimental Capabilities

Example: Transport Validation

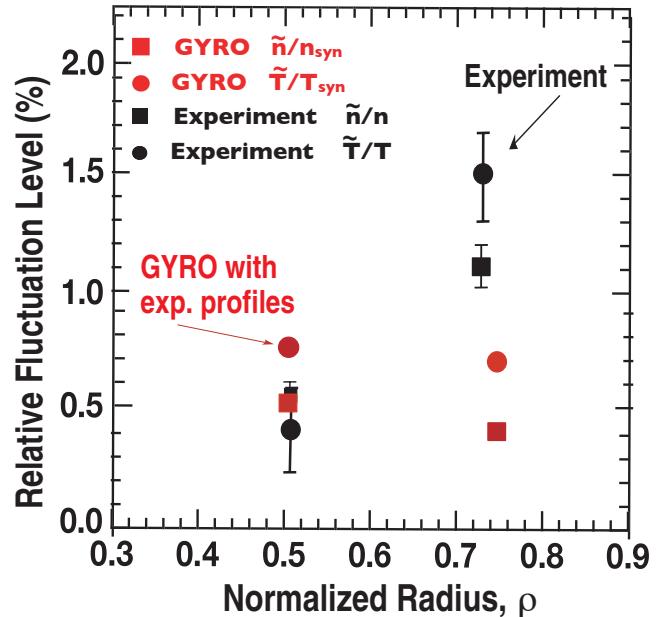


Synthetic Diagnostics Are Essential for Comparison with Experimental Data



Transport Model Validation is a High Priority Research Area in DIII-D Near-Term Plans

- Working group established in 2008
 - Combined effort of theorists and experimentalists
- Studies are focused on validating key aspects of theoretical predictions
 - 2008:
 - Turbulence vs v_* (GYRO)
 - Differentiate roles of $E \times B$ and magnetic shear
 - 2009:
 - Turbulence vs β (GYRO)
 - Zonal flows
 - 2010:
 - Quantitative comparison of $E \times B$ shear stabilization with \tilde{n} , \tilde{T} measurements



- Ultimate goal is the capability to reliably predict transport on ITER

Pedestal Studies Will Focus on Reducing the Uncertainty in Predicting ITER's Pedestal Through Detailed Tests of Edge Transport Models

- Validity of peeling/ballooning stability theory now well established
- Pedestal width is the primary remaining uncertainty in predicting pedestal height (and performance) in ITER

• Plan

2008:

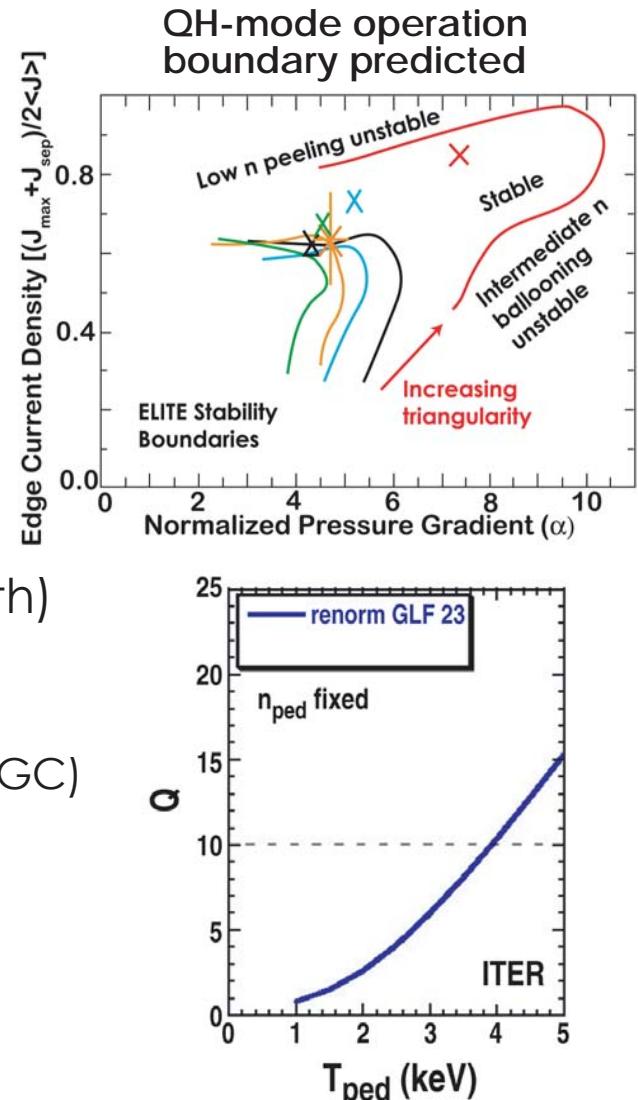
- Initial test of TGLF predictions (turbulence, width)
- Dimensionally similar comparison with JET

2009:

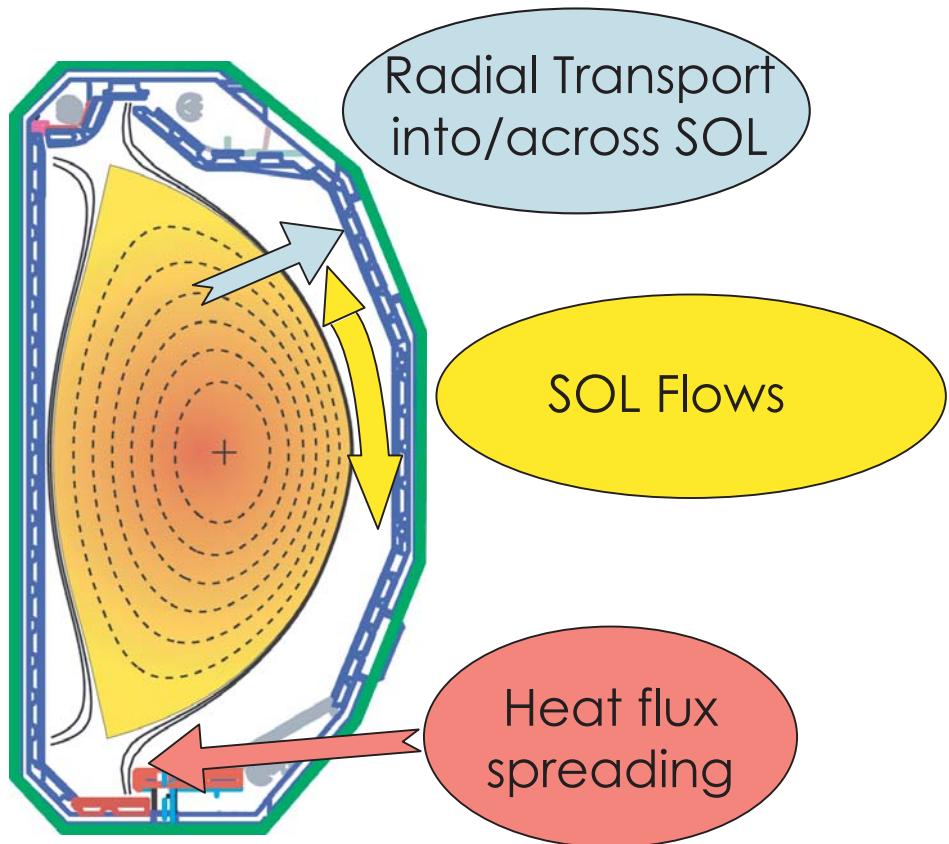
- Begin tests of gyrokinetic codes (EGK, TEMPEST, XGC)

2010:

- Detailed tests of TGLF, gyrokinetic codes



Edge Studies Will Further the Predictability and Control of Divertor Heat Flux

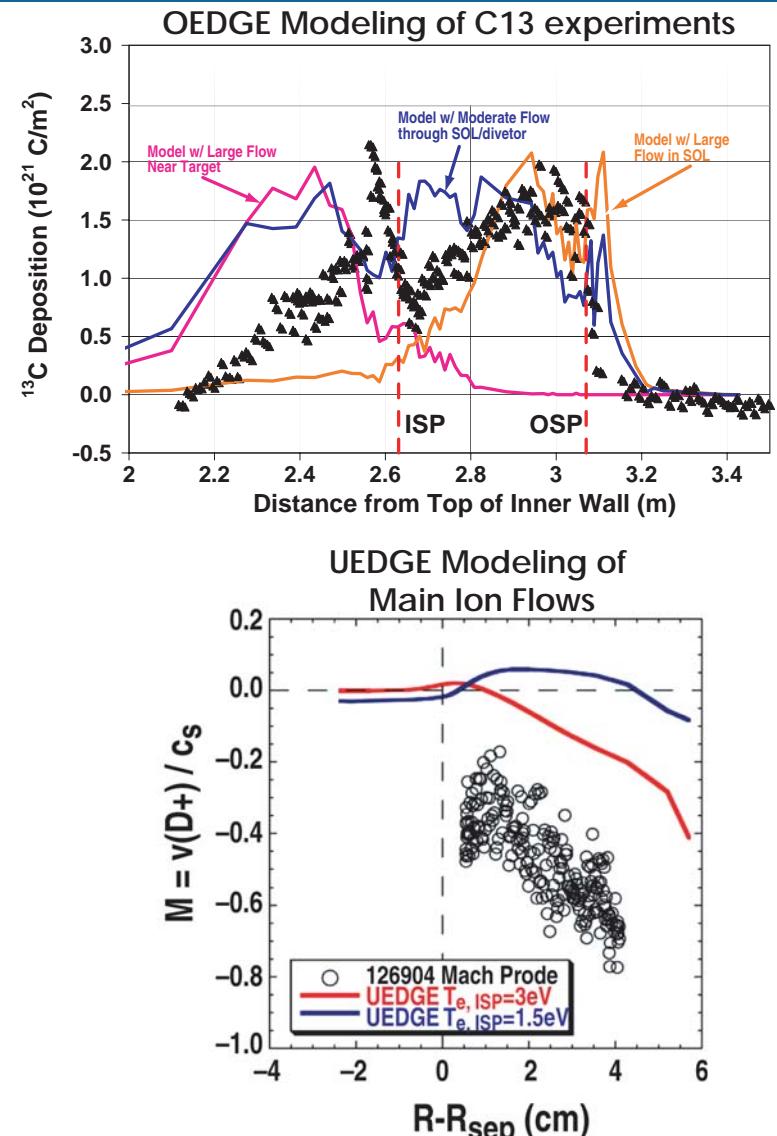


- Leverages DIII-D capabilities:
 - Detailed SOL and divertor measurements
 - Wide range of plasma conditions that can be carefully controlled
 - Open vs closed divertor geometry
 - Non-axisymmetric coils
 - Working group established in 2008
- 2008:
- Radial turbulent heat flux at multiple poloidal locations
 - SOL flows with co/counter NBI, ECH
- 2009:
- Scaling of heat flux with plasma conditions
 - Heat flux broadening with RMPs
- 2010:
- Detailed comparison of turbulence and flows with edge turbulence codes

DIII-D Will Continue to Develop a Better Understanding of What Controls Erosion/Redeposition Patterns

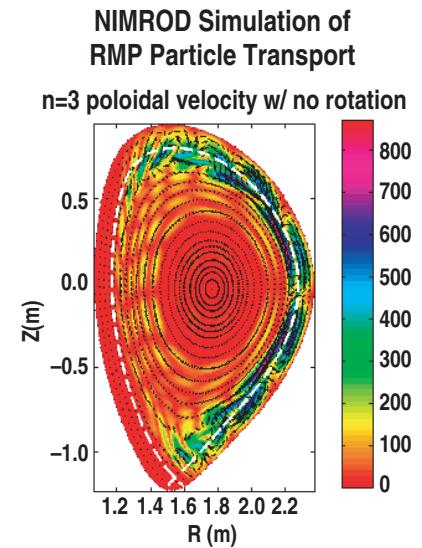
- Modeling of previous C¹³ experiments indicate that a strong poloidal flow is required to explain observations
- Near-term focus will be on physics of carbon migration:

- 2008:
- Assess correlation between SOL flows and carbon redeposition
 - Evaluate link between SOL turbulence and SOL flows
- 2009:
- Compare main chamber erosion with divertor erosion
- 2010:
- Compare detailed mapping of main ion and impurity flows with theory



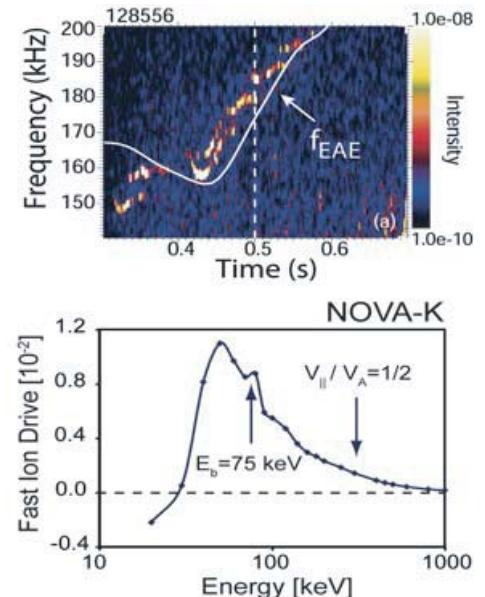
Stability Research will Progress from Ideal MHD to Critical Extended MHD Issues

- Studies will continue to characterize NTM's, ELMs, RWMS, sawteeth, etc.
 - Extended MHD research include:
 - Effects of plasma rotation
 - Non-linear MHD evolution
 - Non-ideal effects
 - 3-D effects
 - State-of-the-art computational tools for detailed theory/experiment comparison
 - Non-ideal effects included in MARS, MBC, NOVA, ELITE
 - Full extended MHD analysis in MH3D, NIMROD
- 2008:
- Validate extended-physics models of sawtooth stability
 - Size and rotation scaling of NTM marginal island size
- 2009:
- Validate extended-physics models of ELM stability
- 2010:
- Assess effect of rotation shear on NTM stability



DIII-D Research Will Identify Energetic Particle Instabilities of Concern for ITER, Characterize Their Impact on Fast Ion Transport, and Seek Methods for Their Mitigation

- Several aspects of experimental observations have been reproduced in theoretical models, E.g.,:
 - TAE, RSAE spatial structure, frequency
 - EAEs driven by low energy beams ($v_b/V_A = 0.25$)
- Some aspects still yet unexplained:
 - Fast ion transport during high AE activity
 - Stabilization of RSAEs by ECH



2008: – Test models of fast ion transport by AEs

- Document n=0 AE with counter NBI

2009: – Assess importance of thermal-ion kinetic effects

- Investigate mechanism for RSAE stabilization by ECH

2010: – Benchmark nonlinear calculations of AE saturation and resulting fast-ion transport

New Capabilities Will Enable Multiple Research Activities

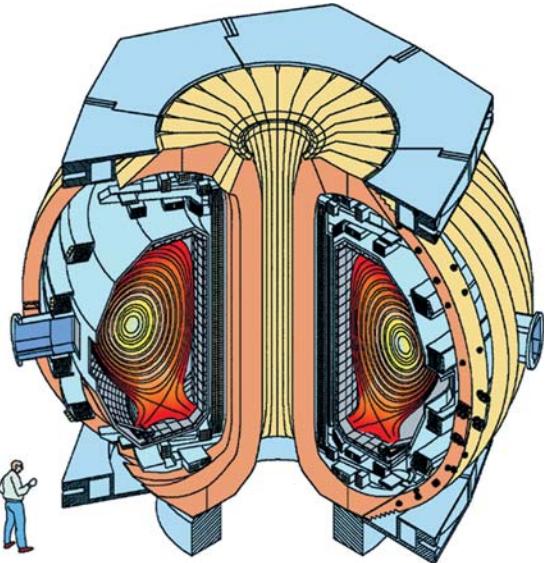
Hardware	Research Elements
NBI: 10 MW, off-axis 20 MW, 10 s	$J(\rho)$, energetic particles, Tor/Pol rotation Long pulse AT
ECH (12 MW, 10 s)	$J(\rho)$, NTM, $T_e \sim T_i$
FW (6 MW, 10 s)	$J(\rho \sim 0)$, $T_e \sim T_i$, energetic particles
Inner Wall RMP	ELM control, heat and particle control
Divertor control coils	Heat and particle control
Divertor and vessel armor upgrade	10 s high performance, physics of heat removal
Hot wall operation	Hydrogenic co-deposition and removal
Custom pellets, inverse jet, liquid jet	Disruption mitigation
RWM amplifier/network	Dynamic error field control, $n=1, 2$ RWM stability
Improved and new diagnostics	Fusion science, control, optimization

DIII-D Long Term Hardware Plan

FY	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Long Term Hardware Goal
Operating Periods	12	15	21	21	21	21	21	21	21	21	
EC	▲ 6 MW				□ R&D 1.5 MW Tube △ Inst. Launcher #4	□ 9 MW		○ 10 MW ○ 11 MW ○ 12 MW			ECH (12 MW, 10 s)
FW	▲ Source Refurbish (4 MW 10 s, 2 MW 2 s)			□ Design New Antenna	□ New Antenna (6 MW, 10 s)			Antenna ABB #1 ○	○ Antenna ABB #2		FW (6 MW, 10 s)
NBI	8th Source Off-Axis Long Pulse Capabilities		△ 20 MW 4 s		□ 5 MW □ 5 MW 10 s □ 10 MW 10 s			○ 15 MW 10 s ○ 20 MW 10 s			NBI: 10 MW, off-axis 20 MW, 10 s
Non-axisymmetric Fields		Prototype △ RMP Coil △ 30° TF Feed		△ Inner Wall RMP							Inner wall RMP
Long pulse	▲ Complete beltbus △ 138 kV Transformer (Aux Pwr 30 MW, 10 s)		△ 12.47 kV Transformer					○ Long Pulse PF Power Supplies			138 kV and 12.47 kV transformers
First Wall				□ Div & Vessel Armor Phase I	□ Div & Vessel Armor Phase II 30 MW, 10 s			○ Div Flux Expansion Coils			Divertor and vessel armor upgrade
High Priority Diagnostics	▲ Upgraded BES △ Fast IR Camera ▲ Fast Thermocouples △ FIDA Upgrade △ Runaway Electrons		△ CECE, Doppler Scattering △ HF-CHERS △ PCI □ 1D Neutrals □ Div/SOL Flows △ ECEI	□ 3D Magnetics □ Escaping Fast Ions □ Surface Station Analysis □ Main Ion CER			○ 2D Neutrals ○ Internal Magnetic Fluctuations ○ Divertor T _i ○ Turbulent Fluxes			Custom pellets, inverse jet, liquid jet Improved and new diagnostics	
<p>▲ = Completed □ = Budget Proposed ▲ = Current budget plus inflation ○ = Program Enhancements</p>											

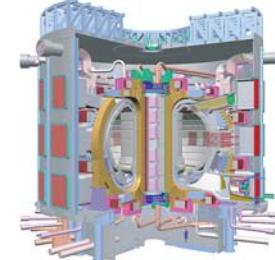
DIII-D Research Plan: An Exciting Opportunity for Significant Scientific Advances Aimed at the Success of Fusion Energy

DIII-D

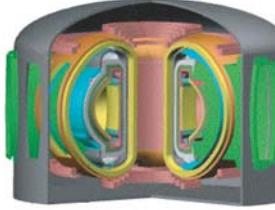


Progress
Will Lead to...

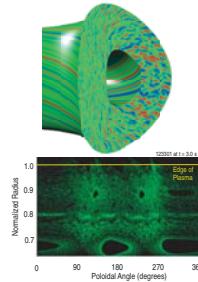
Increased Confidence in
Success of ITER



Improved Basis for
Steady-state Tokamak



Improved Scientific
Understanding
of Key Issues

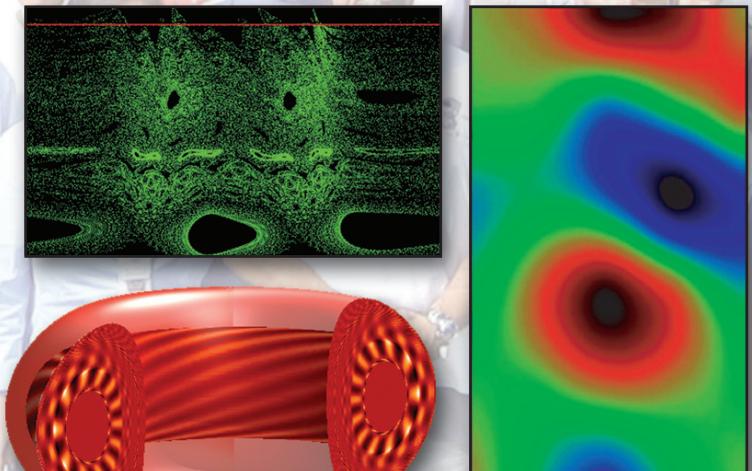
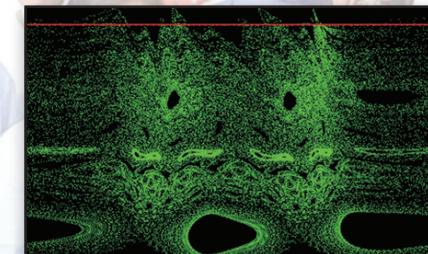


DIII-D Program (Budget and Schedules)

by
T.S. Taylor

Presented at
FY10 Budget Planning Meeting
Office of Fusion Energy Science
Washington, DC

March 11–12, 2008



DIII-D Program Plans, Budgets, and Schedule, Support a World-leading Fusion Research Program

— Three Goals —

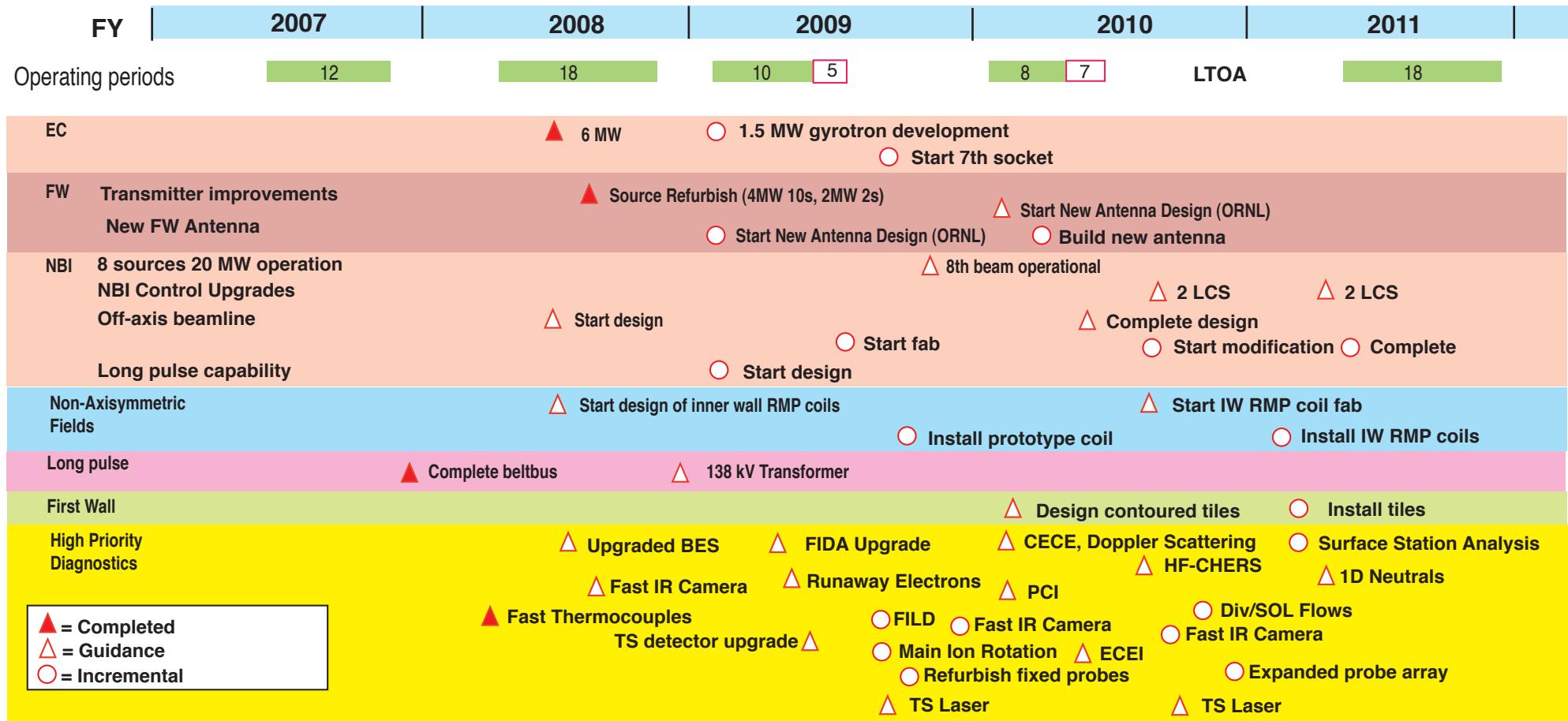
- **Continued Scientific Excellence in advancing fusion energy science**
 - Experimental run time
 - Strong International Team participation
 - Retain outstanding scientific staff
- **Safe, reliable, productive operation of a major U.S. scientific facility**
 - Aggressive maintenance program
 - Modernizations
- **Provide a world-leading scientific instrument for the U.S. and international fusion community for the next decade**
 - Facility upgrades
 - Worldwide contributions on both theory and experiment enhance scientific achievements

➔ Budget request balances investment in

- Run time
- People
- Facility upgrades/modernizations



Guidance Budget Severely Constrains Progress Towards Our Long Term Goals



Refurbishments and Improvements included in the FY09-10 Guidance Budget

- Restore 8 NBI source operation
- Steerable EC launcher (PPPL)
- Rebuild auto transformer
- Design inner wall RMP coils
- Initiate design of off-axis NBI
- Increased FW operations support (GA, PPPL, ORNL)
- DACQ and control systems
 - from CAMAC to PC-based
- Diagnostics
 - Support new University diagnostics
CECE (UCLA) HF CHERS (Wisc.) PCI (MIT), ECEI (UC Davis)
 - Thomson laser and electronics

Budget Reduction in FY09 Seriously Impacts Our Scientific Productivity

— \$3.6 M Reduction —

- Reduction in staff — 10 FTEs
- Reduction in experimental run-time — 10 weeks (from 18)

Our key incremental request will be
to restore scientific productivity

	2009	2010
Retain staff	2550K	2550K
Increased operating time to 15 weeks	1500K	2100K

FY2009 Research Goals

- **10 weeks of operation (guidance budget)**
 - Milestone 168: Particle control and hydrogenic retention with carbon in-vessel components, in support of DOE joint facilities JOULE milestone
 - Milestone 169: Compare disruption mitigation by high-pressure gas injection with theoretical predictions
- **15 weeks of operation (incremental budget)**
 - Milestone 170: Assess candidate profiles for steady-state operation
- **25 weeks of operation (full utilization)**
 - Milestone 171: Evaluate modulated electron cyclotron current drive for stabilizing neoclassical tearing modes
 - Milestone 172: Evaluate off-axis neutral beam current drive

FY09 DOE Joint Facilities JOULE Milestone Addresses Particle Control and Hydrogenic Fuel Retention

Conduct experiments on major fusion facilities to develop understanding of particle control and hydrogenic fuel retention in tokamaks. In FY09, FES will identify the fundamental processes governing particle balance by systematically investigating a combination of divertor geometries, particle exhaust capabilities, and wall materials.

Alcator C-mod operates with high-Z metal walls, **NSTX** is pursuing the use of lithium surfaces in the divertor, and **DIII-D** continues operating with all graphite walls. Edge diagnostics measuring the heat and particle flux to walls and divertor surfaces, coupled with plasma profile data and material surface analysis, will provide input for validating simulation codes. The results achieved will be used to improve extrapolations to planned ITER operation.

DIII-D contributions

- Characterize carbon erosion, transport, redeposition (^{13}C as tracer)
- Particle control with active pumping (SN, DN) and different sources (RF, NBI, Pellet)
- Influence of wall material, geometry, surface temperature (DiMES/MiMES)
- Possible co-deposit removal by thermo-oxidation (“air bake”)
- Compare particle transport and flows with edge models (UEDGE, SOLPS, DEGAS-II, BOUT, ...); range of core and edge regimes
- Compare measured divertor heat flux and upstream profiles to edge models

FY2010 Research Goals

- **8 weeks of operation (guidance budget)**
 - Milestone 173: Evaluate the impact of ITER-like conditions (low rotation, $T_i \approx T_e$) on transport in improved-performance hybrid plasmas
 - Milestone 174: Compare measured fast ion transport by Alfvén eigenmodes to theoretical models
- **15 weeks of operation (incremental budget)**
 - Milestone 175: SOL heat flux profile physics: includes consistency between divertor and upstream parameters and comparison to models
- **25 weeks of operation (full utilization)**
 - Milestone 176: compare variations in pedestal structure and turbulence characteristics with TGLF predictions
 - Milestone 177: Evaluate capability to sustain steady-state operation with $\beta_N > 4$.

DIII-D National Fusion Program Budgets

	<u>FY08</u>	<u>FY09</u>	<u>FY09(I)</u>	<u>FY10</u>	<u>FY10(I)</u>
BUDGET (\$000)	\$61,660	\$58,060	\$8,988	\$59,221	\$10,203
SCIENCE	\$26,982	\$24,877	\$2,960	\$25,252	\$3,080
OPERATIONS	\$34,678	\$33,183	\$6,028	\$33,969	\$7,123
STAFFING (FTE)	174.5	164.1	22.2	163.4	22.0
SCIENCE	80.9	73.2	10.4	72.6	11.4
OPERATIONS	93.6	90.9	11.9	90.8	10.7
RUN WEEKS	18	10	+5 (15)	8	+7 (15)

DIII-D National Fusion Program

Funding by Institution (\$000)

	FY08	FY09	FY09(I)	FY10	FY10(I)
DIII-D PROGRAM	\$61,660	\$58,060	\$8,988	\$59,221	\$10,203
GA	\$46,106	\$42,933	\$7,150	\$43,969	\$8,620
GA CONTRACT SUPPORTED	\$2,511	\$2,754	\$0	\$2,632	\$0
UCLA	\$514	\$514		\$514	
U. MARYLAND	\$30	\$30		\$30	
U.C. IRVINE	\$122	\$122	\$881	\$122	\$881
U. TORONTO	\$136	\$136		\$136	
OTHER GA SUBCONTRACTS	\$79	\$79		\$79	
GA COLLABORATOR SUPPORT	\$1,630	\$1,873		\$1,751	
DOE DIRECT SUPPORTED	\$13,043	\$12,373	\$1,838	\$12,620	\$1,583
PPPL	\$4,421	\$4,100	\$933	\$4,180	\$371
LLNL	\$3,605	\$3,343	\$370	\$3,410	\$370
ORNL	\$2,668	\$2,597	\$300	\$2,649	\$470
UCSD	\$832	\$832		\$849	
U. TEXAS	\$437	\$437		\$446	
COLUMBIA	\$375	\$375		\$383	
SNL	\$215	\$215	\$235	\$219	\$372
U. WISCONSIN	\$340	\$340		\$347	
GEORGIA TECH	\$150	\$134		\$137	
RUN WEEKS	18	10	+5 (15)	8	+7 (15)

DIII-D National Fusion Program

Staffing by Institution (FTEs)

	<u>FY08</u>	<u>FY09</u>	<u>FY09(I)</u>	<u>FY10</u>	<u>FY10(I)</u>
DIII-D PROGRAM	174.5	164.1	22.2	163.4	22.0
GA	128.3	118.6	16.7	117.9	15.8
GA CONTRACT SUPPORTED	133.1	123.2	16.7	122.5	15.8
UCLA	3.5	3.4		3.4	
U. MARYLAND	0.1	0.1		0.1	
U.C. IRVINE	0.7	0.6		0.6	
U. TORONTO	0.4	0.4		0.4	
OTHER GA SUBCONTRACTS	0.1	0.1		0.1	
DOE DIRECT SUPPORTED	41.4	40.9	5.5	40.9	6.2
PPPL	9.5	8.8	2.2	8.8	1.9
LLNL	9.7	10.3	1.3	10.3	1.3
ORNL	7.5	7.8	1.0	7.8	2.0
UCSD	4.7	4.5		4.5	
U. TEXAS	2.0	1.9		1.9	
COLUMBIA	2.3	2.2		2.2	
SNL	2.1	2.0	1.1	2.0	1.1
U. WISCONSIN	3.0	2.9		2.9	
GEORGIA TECH	0.6	0.5		0.5	
RUN WEEKS	18	10	+5 (15)	8	+7 (15)

DIII-D National Fusion Program: Budgets for 10% Reduction

	<u>FY08</u>	<u>FY09 GUIDANCE</u>	<u>FY10 -10%</u>	<u>FY10 GUIDANCE</u>	<u>FY10 INCREMENTAL</u>
BUDGET	\$61,660	\$58,060	\$53,300	\$59,221	\$69,424
SCIENCE	\$26,982	\$24,877	\$24,536	\$25,252	\$28,332
OPERATIONS	\$34,678	\$33,183	\$28,764	\$33,969	\$41,092
STAFFING (FTE's)	174.5	164.1	154.4	163.4	185.4
SCIENCE	80.9	73.2	70.6	72.6	84.0
OPERATIONS	93.6	90.9	83.8	90.8	101.5
RUN WEEKS	18	10	0	8	15

Impact of 10% Cut in the DIII-D National Fusion Program FY09/FY10

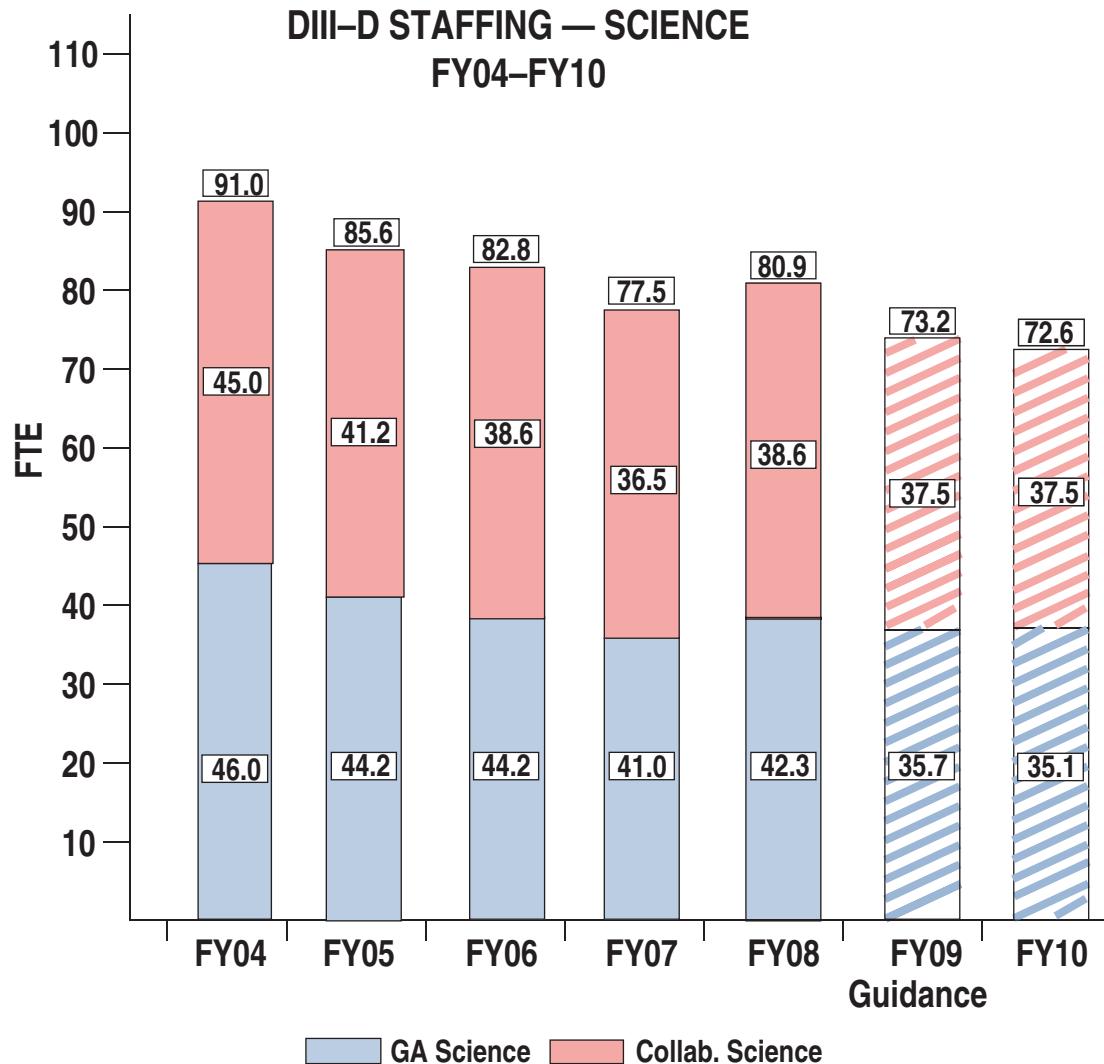
In FY09, the following actions will be in the order listed:

1. Delay refurbishment DACQ and control systems
2. Delay of refurbishment of autotransformer
3. Delay FW antenna design
4. Delay Thomson detector electronics upgrade
5. Delay Thomson laser replacement
6. Reduce run-time from 10 weeks to 6 weeks
7. Further staff reduction ~12 FTEs (8 GA)

In FY10, the following actions will be in the order listed:

1. Delay refurbishment DACQ and control systems
2. Delay of refurbishment of autotransformer \$473k
3. Delay FW antenna design
4. Delay purchase of Thomson lasers
5. Reduce run-time to 0 (from 8 weeks)
6. Further staff reduction ~9 FTEs (5 GA)

Retaining Scientific Staff is Critical to Support a Vital Research Program

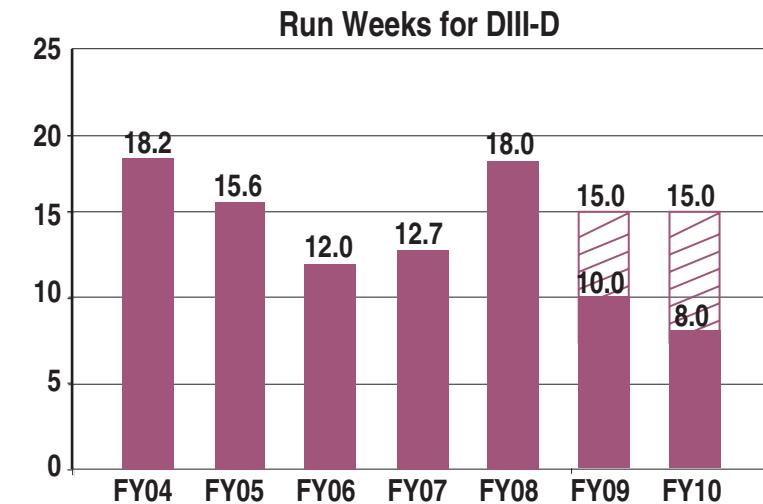


- Losing excellence
- Losing the future

Increased Runtime Would Allow More Excellent Experiments to be Completed

Many excellent proposals were received for 2008

Area	Proposals Received	Unique Proposals	Proposals in 18 week plan	Scheduled (%)
ITER Demonstration Discharges TF	17	15	7	47
Rotation Physics TF	62	31	11	35
ELM Control and Pedestal Physics TF	80	76	12	16
ITER Physics	67	61	17	28
Steady-State Integration	63	58	11	19
Fusion Science	153	130	14	11
Integrated Modeling	3	3	2	67
Plasma Control and Operations	26	23	5	22
Total Proposals	471	397	79	20



- The program should get to 25 run weeks (full utilization)
- The increased experimental time in FY08 is greatly appreciated

Full Utilization of the DIII-D Facility Provides 25 Weeks of Operation

	<u>FY08</u>	<u>FY09</u>	<u>FY09(I)</u>	<u>FY09 FULL UTILIZATION</u>	<u>FY10</u>	<u>FY10(I)</u>	<u>FY10 FULL UTILIZATION</u>
BUDGET (\$000)	\$61,660	\$58,060	\$8,988	\$13,538	\$59,221	\$10,203	\$14,753
SCIENCE	\$26,982	\$24,877	\$2,960	\$4,135	\$25,252	\$3,080	\$4,255
OPERATIONS	\$34,678	\$33,183	\$6,028	\$9,403	\$33,969	\$7,123	\$10,498
STAFFING (FTE)	174.5	164.1	22.2	31.2	163.4	22.0	31.0
SCIENCE	80.9	73.2	10.4	13.4	72.6	11.4	14.4
OPERATIONS	93.6	90.9	11.9	17.9	90.8	10.7	16.7
RUN WEEKS	18	10	+5 (15)	+15 (25)	8	+7 (15)	+17 (25)

Summary of DIII-D Program Incremental Budget Requests

	FY09	FY10
Retain Scientific Staff	\$2,550K GA LLNL \$2,450K \$100K	\$2,550K GA LLNL \$2,450K \$100K
Increased Operating Time Facility Operations	\$1,500K (To 15 Weeks) GA \$1500K	\$2,100K (To 15 Weeks) GA \$2,100K
Add Students/Postdocs	\$410K GA, LLNL, PPPL, SNL \$410K	\$530 K GA, LLNL, ORNL, PPPL, SNL \$530K
Neutral Beam Systems Off-axis NBI Long Pulse NBI (initiate design)	\$1,050K GA \$900K GA \$150K	\$1,550K GA \$1400K GA \$150K
Inner Wall RMP Prototype Install 48 Coil Set	\$350K GA \$350K	\$750K GA \$750K
ECH Installation of 7th Socket Procure 1.5MW Gyrotron Long Pulse ECH Launcher Mirror	\$1486K GA GA PPPL \$850K \$550K \$86K	\$1,571K GA GA PPPL \$425K \$935K \$211K
Fast Wave Antenna Replacement Antenna Replacement Design FW Operations support	\$358K ORNL PPPL \$300K \$58K	\$410K ORNL PPPL \$350K \$60K
Diagnostic Refurbishments/Upgrades Bolometer and SXR DACQ Magnetic probe DACQ Fast Ion Loss Detector SOL Impurity Ion flow spectroscopy Fast IR TV for ELMs and DN operation Main Ion rotation diagnostic Refurbish fixed probe array Expanded probes and calorimeters	\$1,284K GA GA LLNL PPPL SNLA \$35K \$275K \$150K \$689K \$135K	\$742K GA GA LLNL SNLA SNLA \$35K \$285K \$150K \$157K \$115K
Totals	\$8,988K	\$10,203K

DIII-D: A World Class Program Committed to the Success of ITER and Advancing Fusion Energy Science

- The realization of a burning plasma tokamak experiment (ITER) promises an exciting and challenging future for Fusion Energy Science
- DIII-D is an excellent research vehicle to lead the US into the ITER research program
 - Unique features to provide physics solutions to key ITER issues
 - Relevant plasma parameters, configurations, and control tools
 - Extensive diagnostics and control capabilities to develop detailed physics basis for ITER operation
 - Development of integrated scenarios that will inform ITER operation and decisions on next-step options